THE FUTURE OF THE SALTON SEA UNDER PROPOSED LOWER COLORADO RIVER BASIN WATER MANAGEMENT SCENARIOS

A Dissertation

by

MICHAEL EDWARD KJELLAND

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2008

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	William E. Grant
Committee Members,	Ann L. Kenimer
	R. Neal Wilkins
	X. Ben Wu
Head of Department,	Thomas E. Lacher, Jr.

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ABSTRACT

The Future of the Salton Sea Under Proposed Lower Colorado River Basin Water Management Scenarios. (December 2008)

Michael Edward Kjelland, B.A., Valley City State University;

M.S., North Dakota State University

Chair of Advisory Committee: Dr. William E. Grant

The Salton Sea, situated in the Lower Colorado River Basin (LCRB), is under duress due to, among other things, increased water demands of cities like San Diego, California and Mexicali, Mexico. This research developed a tool to investigate the implications of water transfers on the health and sustainability of the Salton Sea Ecosystem.

The Salton Sea model is a spatially-explicit, stochastic, simulation model representing water flow, i.e., water volume and quantity of Total Dissolved Salts (TDS) and Phosphorus (P), in the LCRB as it enters the Salton Sea. The model is formulated as a compartment model based on difference equations with a daily time step using STELLA® 8.0 software. The model was developed, evaluated, and applied to simulate the potential effects on the population dynamics of selected fish and avian species at the Salton Sea under six different scenarios. Oneway ANOVAs and Bonferroni Multiple Comparison Post Hoc Tests were performed for the water management scenarios and

selected variables involving the fish and bird population dynamics using SPSS version 12.0.1 (SPSS Inc., 2003).

Weather station daily data were collected for both precipitation and Eto for a 25-year period (1980-2004) for the Salton Sea area. Thirty-four probability distributions were fit to the monthly datasets. Monthly distributions were used to preserve seasonality when modeling future climate scenarios. Additionally, binomial and multinomial logistic regression models were utilized to determine the relationships concerning precipitation events and Eto levels. Further, two strategies were employed in modeling the uncertainty in future climate patterns, namely deterministic and stochastic versions of the driving variables. A climate sensitivity analysis was also conducted and results showed that the cumulative effects and change of plus or minus 10 percent in Salton Sea inflows can have significant effects on sea elevation and salinity.

Both of the Salton Sea impoundment scenarios significantly ($P<0.05$) lowered the salinity in the north or main sea impoundments compared to future downward trends in sea elevation and upward trends in salinity under baseline conditions. Further, the elevations of the north or main sea impoundments were stabilized at -220 by the end of 2024. Should action be taken to stabilize the sea and reduce salinity, the impoundment scenarios demonstrated the most success in the present study. If no such action is taken, the simulation results demonstrate that the current community dynamics of the Salton Sea will be further impaired as a result.

DEDICATION

I dedicate this dissertation to Dr. Damion E. Marx (Ph.D.) (4/13/1972 - 3/13/2008). Damion was a good example of how the kind side of the human spirit can truly touch others and inspire others to do the same. He was a proponent for common sense, an advocate for conservation, and a good friend. I find it hard to believe that I am writing about him under these circumstances, and not sitting around a campfire or BBQ grill discussing some philosophical issue with him. I can practically hear him right now, "did you ever read…", or "the human will is the fundamental variable…..", or "Theocritus (ancient Greek literature) said something to the effect of….." He, along with three others, died in a plane crash while performing aerial surveys of wading birds as part of a study involving Lake Okeechobee.

"Keep away from people who try to belittle your ambitions. Small people always do that, but the really great ones make you feel that you too, can become great."

~ Mark Twain

ACKNOWLEDGMENTS

I would like to extend a special "thank you" to my advisor Dr. William E. Grant whose patience, insight, and reviews of my dissertation were greatly appreciated. I would also like to express my gratitude to the other members of my committee: Dr. Robert Neal Wilkins, Dr. Xinyuan Ben Wu, and Dr. Ann L. Kenimer for their insights and suggestions. I would like to thank Dr. Craig Forster, the "unofficial" honorary member of my doctoral committee. And I might add, the only member that took me back 350 million years in time, in terms of the geologic strata, to search for Trilobites in Utah.

I would like to thank my family and friends for coping with my absence from many events due to my research and graduate studies. I would like to extend much thanks to Amy Hays, Dale Kubenka, Dr. Todd Swannack, Dr. Miguel Mora, Dr. Edith Gonzalez Afanador, Dr. Michael Longnecker, Dr. Mathias Tobler, Dr. Patricia Smith, Anil Shakya and Rajani Shakya, and Dr. Tulia Defex for their valuable help. Lastly, I would like to thank everyone else at the Texas A&M University Department of Wildlife and Fisheries Sciences that aided me in my graduate career. I would also like to express my gratitude to the Southwest Consortium for Environmental Research and Policy (SCERP) that sponsored my research through a cooperative agreement with the U.S. Environmental Protection Agency.

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CHAPTER I

INTRODUCTION

The terminal lake ecosystem of the Salton Sea is located in the southeastern corner of California (Fig. 1), only 30 miles from the U.S.-Mexico border (Tetra Tech, Inc., 2000). The Salton Sea is a major hydrologic element of the Lower Colorado River Basin and is considered important to the economic, social, and biological values of the region. However, it is suffering marked degradation as a consequence of human activity and although efforts to rehabilitate the Salton Sea ecosystem have been underway for more than a decade, they have had little success. "Once one of the biologically richest and most diverse areas in North America, the lower Colorado River region now is one of the most degraded ecosystems in the United States"- Daniel Anderson, Professor of Wildlife, Fish & Conservation Biology, University of California, Davis (Vincent, 2000).

Increased water demands of cities like San Diego, California and Mexicali, Mexico have resulted in declining levels of aquifers, increased nutrient and contaminant loading of streams in the Lower Colorado River Basin, decreasing freshwater inflow to the Salton Sea, and the loss of endemic species. Plans to meet the increasing water demands include lining the All American Canal with concrete to reduce losses as water is moved from the Colorado River to San Diego, fallowing farmland in the Imperial

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This dissertation follows the style of Ecological Modelling.

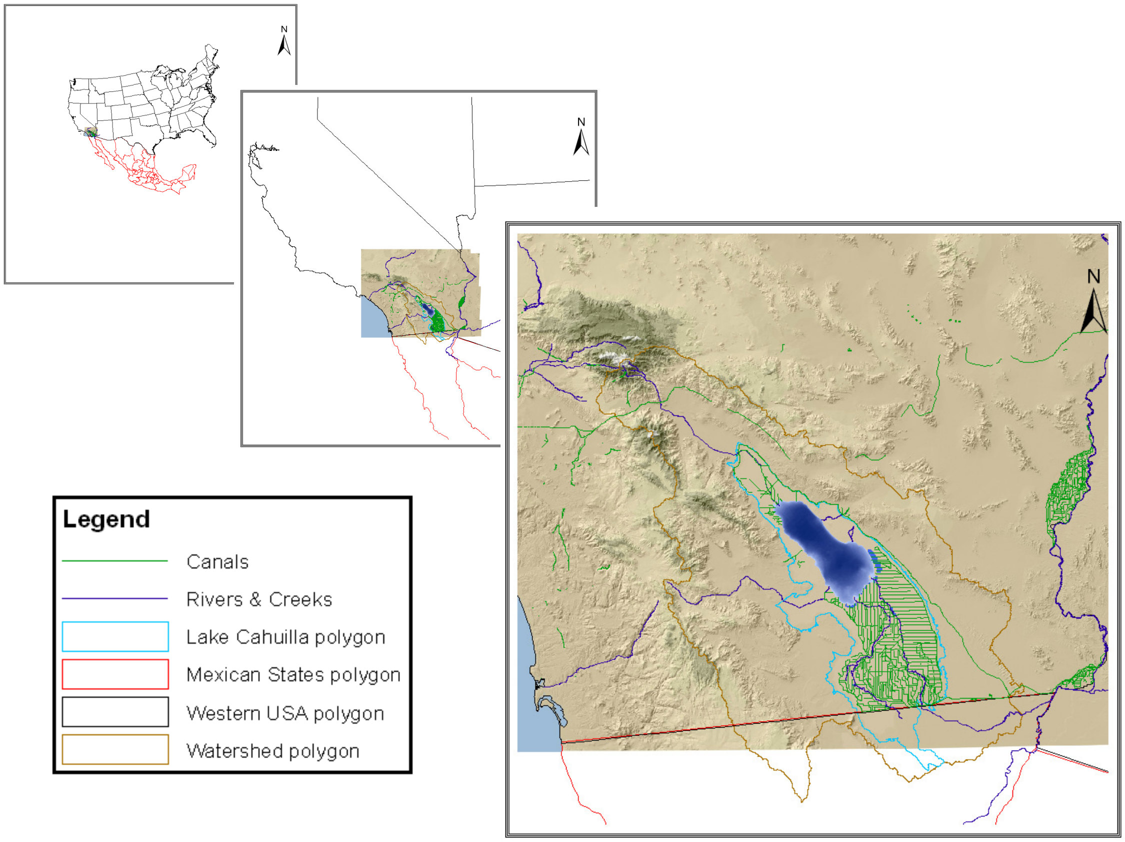

Fig. 1 - Salton Sea geographic location.

Valley to reduce agricultural water use, and diverting water from the New River to operate the newly constructed power plants in Mexicali, Mexico. Plans to improve water quality include passing wastewater through a recycling plant in Mexicali, increasing the number of wetlands through the New River Wetlands Project, and extracting brine (salt) from the Salton Sea.

The goal of this research was to develop an integrated systems simulation model to create a more effective tool for managing the complex environmental and natural resource problems in the Salton Sea Basin of the Lower Colorado River Basin.

Background Information

On January 1, 2002, the Department of the Interior cut off California's access to any Colorado River water above its 4.4 million acre-foot share (4.4 Plan). One of those hardest hit was the water agency that serves San Diego, which will lose nearly half of the water it has used in the past (McKinnon, 2002). Since current annual California water usage is about 5.2 million acre-feet, this would mean losing 800,000 acre-feet of water per year, enough to support around 5 million people (Spillman, 2002). A water transfer from Imperial Valley to San Diego has been proposed as a result, and raises serious concerns regarding the future ecosystem health of the Salton Sea. Under the water transfer, a multibillion-dollar plan has been agreed upon to move up to 300,000 acre-feet of water annually from Imperial Valley farms to homes in San Diego and the Coachella Valley (Spillman, 2003). This will impact agricultural production in the region, which is one of the richest agricultural centers in the nation and provides much of the country's wintertime vegetables (Polakovic, 2001). Moreover, commercial agriculture plays a large role in maintaining the Salton Sea, as the sea is sustained primarily by agricultural drainage from the Imperial, Coachella, and Mexicali valleys, with some contribution from municipal effluent and stormwater runoff (Salton Sea Authority - Salton Sea Restoration Project, 2001a). Since the sea is largely replenished by agricultural runoff, it stands to shrink as inflows are reduced from about 1.3 million-acre-feet annually to 1 million acre-feet (Spillman, 2003).

A major concern is that as the Salton Sea receeds and exposes contaminated sediments; they might be dispersed in dust storms throughout the surrounding communities. Imperial County already struggles to contain health-degrading air pollution, with about 250 tons of smoke and dust released into the air daily (Polakovic, 2001). In addition, the enhanced salinity of the diminished return flows will accelerate the increasing salinity of the sea that, in turn, will affect the viability of avian and fish habitats. An alternative scenario proposed to counteract the anticipated salinity increase of the conservation-based approach is to fallow agricultural land (perhaps by as much as 20%) while maintaining current inefficient irrigation practices so that agricultural return flows, although reduced in magnitude, will not suffer an increase in salinity. The decline in employment associated with fallowing agricultural land, however, will lead to a severe impact on the already distressed economy of the Imperial Valley.

Furthermore, the Salton Sea lies at a nexus of bi-national water supply/quality issues. For example, water flowing in the New River to the sea is largely derived from municipal wastewater discharged upstream by Mexicali, Mexico. Plans to reclaim wastewater for various uses, including cooling water for two new power plants in the Mexicali Valley, are expected to lead to reduced flows in the New River. In addition, a proposal to line the All American canal (supplied with water diverted from the Colorado River), intended in part to reduce the volume of water that must be obtained from Imperial Valley agriculturalists, will lead to a decline in the trans-border movement of groundwater available to farmers and ranchers in Mexico.

All of these complex issues can be incorporated into a simulation model to create a more effective tool for managing the complex environmental and natural resource problems facing the Lower Colorado River Basin. Further, different scenarios of dividing the Salton Sea with dikes, an option proposed by engineers, can be implemented in the model to determine the costs and benefits of such actions before any construction project has been implemented.

Objectives

The overall objective was to develop a mass-balance, stochastic simulation model to address national and bi-national environmental and natural resource management issues affecting the Salton Sea in the Lower Colorado River Basin. The model simulates rates of water flow, both water quantity and quality, in the Lower Colorado River Basin and avian and ichthyan population dynamics in the Salton Sea Basin under various scenarios, including lining the All American Canal with concrete (reducing recharge to groundwater in Mexico) and fallowing farmland in the Imperial Valley (reducing water inflow to the Salton Sea), operating the newly constructed power plants and the proposed wastewater recycling plant in Mexicali, Mexico (reducing the flow of water into the New River), increasing the number of wetlands in the New River Wetlands project (improving water quality but reducing water inflow to the Salton Sea), incorporating proposed methods of brine extraction from the Salton Sea (reducing salinity but decreasing water volume). In order to accomplish this objective, it was necessary to collect, organize, and analyze both spatial and temporal data (daily) for a 25 year period from 1980 through 2004. The result is a simulation model that incorporates seasonality, unlike previous models that have been constructed for the Salton Sea which rely on datasets consisting mainly of annual averages.

This dissertation is organized in chapter format in a step-by-step progression to achieve the overall objective identified in Chapter I of the Introduction. The second chapter provides a detailed method for using a geographic information system (GIS) to create the Salton Sea impoundment scenarios, including the calculation of the individual bathymetries for each impoundment, i.e. elevation, surface area, and volume relationships. The simulation model results, i.e. Salton Sea and/or impoundment water volumes, are then entered into the GIS to provide a spatial context of the effects of water policy decisions in terms of the following scenarios: (1) no action (baseline), (2) south Salton Sea impoundment, and (3) south impoundment within the Salton Sea. The third chapter addresses the relationships between precipitation and evapotranspiration (Eto) in the Salton Sea Basin using nominal and categorical variables implemented in a polynomial regression model. The assumptions used in the simulation model for projecting precipitation, Eto, and river flows in future climate scenarios are also addressed. The fourth chapter examines the hydrologic components of the mass-balance simulation model. The fifth chapter examines the avian and ichthyan sub-model components of the simulation model. Lastly, the sixth and final chapter provides a discussion of the results and the conclusions drawn from this research.

CHAPTER II

SALTON SEA ECO-ENGINEERING: CONSTRUCTING IMPOUNDMENT SCENARIOS AND ASSOCIATED BATHYMETRIES USING A GEOGRAPHIC INFORMATION SYSTEM

This study designed Salton Sea impoundment scenarios using a Geographic Information System (GIS). The impoundment scenarios were later incorporated into an integrated systems simulation model that included agricultural, social, demographic, hydrologic, climate and ecological components. In this manner, the simulation model results, i.e. projected Salton Sea water volumes, were displayed in both a spatial and temporal context.

With hydrology and environmental engineering projects it is important to be able to perform analyses of proposed projects and the associated costs and benefits that may result from them. In terms of efficiency and accuracy, simulation models may be created that allow for these analyses, that is, the changes in hydrology and the potential effects on the environment. The concomitant use of GIS and simulation modeling software is becoming a common practice. Simulation models can be powerful tools for the analysis of watershed processes and their interactions, and for the development and assessment of management scenarios at the watershed scale (He, 2003). However, there exist unique aspects of water resource management problems that necessitate a special approach to GIS data structure and expanded development of GIS applications for handling water resources management analysis in a GIS (McKinney and Cai, 2002).

Specifically, fluctuations in 3-dimensional volumes, the creation of impoundments and resultant changes associated with elevation, surface area, and volume correlations, and salinity gradients all require special technical approaches compared to 2-dimensional analyses, e.g. habitat configurations and diversity indices.

Recent advancements in computer technology and associated software are making it ever easier, and as a result more efficient, to incorporate engineering plans into ecological analyses, essentially allowing the reconstruction of different engineering scenarios in the conceptual stages. Previously, engineering projects were constructed and ecologists were often left with analyzing environmental consequences after the fact, in essence, being left with stopgap and mitigation measures. Ecologists and others in charge of managing natural resources now have an increased capability to analyze different engineering scenarios in the conceptual stages, receive feedback, and be part of the engineering process, essentially becoming eco-engineers providing environmental decision support systems. These environmental decision support systems and their application are becoming more prevalent in the scientific literature primarily due to the ongoing advances in data quantity and availability along with innovative technologies. For instance, Newham et al. (2004) used GIS to create an integrated framework for hydrologic, sediment and nutrient export modeling for catchment scale management (Matthies et al., 2006). In another example, Schlüter et al. (2005) integrated a hydraulic network model with a habitat suitability index to assess the restoration of riparian forests in the Amurdaya delta (Matthies et al., 2006).

The ability to implement a project in a GIS digitized environment and then incorporate a simulation model can lead to increased accuracy in the projected consequences of many different scenarios. In this paper, a method is demonstrated that greatly decreases the amount of time spent on calculating surface area, volume, and elevation correlations using GIS and simultaneously increasing accuracy of the calculations. The results are subsequently used to illustrate different scenarios in a simulation modelling project involving the impoundment of the Salton Sea as a potential means of controlling increasing salinity levels. The Salton Sea is just one such example of a complex system whereby this method may be incorporated.

Background Information

The Salton Sea is located in southeastern California (33º 15' N, 116º W) approximately 35 miles (56 km) north of the U.S.-Mexico border (Cohen and Hyun, 2006). The Salton Sea is a terminal lake, meaning that the only natural outlet for water to leave the sea is via evaporation. The Salton Sea watershed spans some 8,360 square miles (21,700 km^2) and extends from San Bernardino County through Riverside and Imperial counties and into the Mexicali Valley, in Baja California, Mexico (Cohen et al., 1999). It is estimated that more than 75 percent of Salton Sea inflows come from agricultural field drainage irrigated with Colorado River water (Cohen et al., 1999).

The Salton Sea is a major hydrologic element of the Lower Colorado River Basin (LCRB) and is considered important to the biological, economic, and social values of the region. Although efforts to rehabilitate the Salton Sea ecosystem have been underway for more than a decade, its degradation continues as a consequence of human activity. Furthermore, the Salton Sea lies at a nexus of binational water supply/quality issues. Increased water demands of cities like San Diego, California and Mexicali, Mexico have resulted in declining aquifer levels, increased nutrient and contaminant loading of streams in the LCRB, decreasing freshwater inflow to the Salton Sea with subsequent rising salinity levels, and the loss of endemic species. The myriad of problems continues to threaten the region's ecosystem as evidenced by large die-offs of both aquatic and avian species in the area (Cook and Orlob, 1997).

Agricultural fallowing, brine extraction, and impoundments are all possible scenarios that have been discussed, but it is the latter that is the focus of this chapter. There are several considerations that need to be accounted for when trying to address a solution for the Salton Sea's problems by using impoundments. From an engineering standpoint, impoundments must be engineered to counter seepage and withstand earthquakes (Figs. A.1 & A.2 in Appendix A). Also, from an ecological perspective, plans must take into account the locations of Parks, wildlife areas and wildlife refuges (Fig. A.3 in Appendix A), other habitat for species of concern, i.e. Desert Pupfish (Fig. A.4 in Appendix A) and California Clapper Rail (Fig. A.5 in Appendix A) habitat, and wetland areas around the sea (Fig. A.6 in Appendix A). In terms of socio-economic terms, not only does the wildlife component play an important role in bringing in tourism dollars in the form of bird watching, fishing, and hunting, but also the marinas and camping areas (Fig. A.7 in Appendix A) must be included in any plan to divide the sea into separate impoundments. Further, the Torres-Martinez Native American refuge lies near and on the north end of the sea. Also, real estate owners along the beaches of the Salton Sea, especially in places like Salton City, stand to lose economically should the sea become hyper-saline or the sea impoundments be placed in ways that reduce beachfront aesthetics.

The goal of this research was to develop impoundment scenarios in a GIS that could be used in conjunction with a simulation model in order to address some of the complex environmental and natural resource management problems in the LCRB. The outcome is a more effective tool for managing the complex environmental and natural resource problems facing the LCRB, and more specifically the Salton Sea.

Methods

We first obtained base maps and in particular a shapefile containing the bathymetric data for the Salton Sea from the University of the Redlands Institute. Shapefiles contain vector data stored as X, Y, and Z coordinates to define simple, discrete geometry such as points, lines, and polygons (Environmental Systems Research Institute, Inc., 1998). The Salton Sea bathymetric data consisted of shapes (polygons), each having an area and perimeter (X and Y coordinates), acreage, and one-foot elevation contour intervals (Z coordinates), e.g., -227 to -228 feet above sea level (fasl). Next, the Salton Sea bathymetry shapefile was imported into ArcView version 3.1 and displayed in the view (Fig. A.8 in Appendix A). The ArcView extensions ‘X-Tools’, ‘GeoProcessing’, and ‘3D Analyst’ were used to create three impoundment scenarios for the Salton Sea that could be integrated with simulation model results.

Creating Two Separate Polygons from a Single Polygon (Scenarios 1 & 2)

First one begins by selecting the theme of interest, followed by ‘Theme’ and ‘Start Editing’ and then selecting the ‘Creates a Polygon on the Display’ symbol. Second one creates a new polygon by selecting one half of the sea, thereby intersecting the sea area where it is to be divided. Once one half of the sea has been selected, then the Salton Sea shapefile ‘Salton Sea Theme’ is unselected, so that the image of the bathymetry of the sea no longer appears on the display, and only the newly created polygon remains. The third step is to go to ‘View’ and select ‘New Theme’ and give the shapefile a new name and choose the desired directory where it will be stored. The new shapefile, with the newly created polygon representing one half or a portion of a split sea, is then imported to the display as the fourth step. Now, the newly created shapefile theme is active, and we also reactivate the ‘Salton Sea Theme’ (original theme). The fifth step is to select the ‘appends a new polygon adjacent to other polygons’ symbol that is located on the same scroll down menu of the ‘Creates a Polygon on the Display’ symbol menu. Subsequently, one draws a line, beginning within the first polygon, around the second half of the sea area, ending with a double click inside the first polygon, thus forming and appending the second polygon to the first (Fig. A.8B in Appendix A). (Note: In version 9 of ArcGIS one needs to use ‘Append another polygon to an existing polygon’ at the bottom of the polygon shapes tool list, e.g. square, circle and so forth.) Finally, once the second polygon has been appended, inactivate the ‘Salton Sea Theme’ so that only the two polygons remain on the display, and go to ‘Theme’ and select ‘Convert to Shapefile’ thereby creating a new shapefile. Import the new shapefile to the view and display it, and select the ‘Salton Sea Theme’ (Figure 8C in Appendix).

The next set of steps uses an extension called ‘X-Tools’. First, using ‘X-Tools’ select the ‘Update Area, Perimeter, Hectares, and Length’ option and a pop up will be displayed called ‘Calculate Feature Size’. Second, one selects the newly created shapefile for which the calculations will be made, thereby automatically updating the attribute table. Third, open the attribute table of the theme of interest and change the newly created ‘ID’ field (column) to 1 and 2, representing each of the two halves of the sea, i.e. the two different polygons (Fig. A.9 in Appendix A). To edit, go to ‘Table’ and select ‘Start Editing’ and after edits have been made ‘Save Edits’. Afterward one needs to go to ‘View’ and select the ‘GeoProcessing Wizard’ and then select the ‘Intersect Two Themes’ option (Fig. A.9B in Appendix A) to create a new shapefile, rename it (‘Theme’ and select ‘Convert to Shapefile’), and then use ‘X-Tools’ and select the ‘Update Area, Perimeter, Hectares, and Length’ option and a pop up will be displayed called ‘Calculate Feature Size’. In step four, one selects the newly created shapefile for which the calculations will be made. The shapefile is now complete, with the information of the sea as a whole, now divided as to pertain to the north polygon of the sea, and the south polygon of the sea, i.e. north and south sea impoundments. Finally, rename the shapefile thus creating two more shapefiles, one to be used for the north impoundment, and one for the south impoundment. Next, sort the attribute tables of the shapefiles, and delete the rows that pertain to the north identification (ID) number to create a shapefile of only the north polygon of the sea (Fig. A.10 in Appendix A), and likewise for the south polygon of the sea (Fig. A.10B in Appendix A). Both shapefiles displayed at the same time should be the same as the display of the whole Salton Sea, only partitioned into two separate halves (Fig. A.10C in Appendix A). When linked to simulation modeling results, the two halves will operate as two separate water bodies separated by a dike (Fig. A.10D in Appendix A).

Creating a Polygon Within a Polygon (Scenario 3)

To create a south impoundment polygon within the Salton Sea polygon, i.e. a smaller polygon within a larger polygon, the extension X-tools was used to convert graphics to shapes using the 'graphics to shapes' command and thus creating a new shapefile. Next the elevation of interest was selected in the attribute table thereby highlighting its location on the display (Fig. A.11A in Appendix A). Thereafter, dots were placed along the -245 foot above sea level elevation dike (Fig. A.11B in Appendix A). Afterwards, a polygon of the diked impoundment, at -245 foot above sea level, was created by connecting the dots (Fig. A.11C in Appendix A). Next, the 'Geoprocessing Wizard' was used, selecting union two themes, and then in the attribute table of the theme, one deletes rows pertaining to the polygon, e.g. north or south impoundments, that needs to be removed.

Then using the 'X-Tools' extension one selects the 'Update Area, Perimeter, Hectares, and Length' option. A new display will appear called 'Calculate Feature Size' and one selects the newly created shapefile for which the calculations will be made, thereby updating the attribute table. Next, the attribute table of the theme of interest is opened and the newly created 'ID' field (column) is changed, e.g. 3, for this new polygon shape of the sea and re-named by going to 'View' and selecting 'Convert to Shapefile'.

Lastly one uses the extension 'X-Tools' and 'convert shapes to graphics' for one polygon, and then selects the other theme of interest so that both polygons appear on the display. The second polygon is also converted to a graphic using the same procedure. Once both polygons have been converted to graphics, inactivate both themes and convert the graphics to shapes using 'convert graphics to shapes' function under 'X-Tools.' The new shapefile is given a name and directory and imported to the view (Fig. A.11D in Appendix A). The result is that each polygon has been joined into a single shapefile, but both polygons pertaining to the north and south impoundments each have a separate ID (Fig. A.12A-D in Appendix A).

Converting Shapefiles to TIN Files

To convert a shapefile to a triangulated irregular network (TIN) file, one simply uses the command 'Convert shapefile to TIN' and after the conversion is finished the TIN file is saved and imported into the view. There are several options when converting a shapefile to a TIN file. Features used in the triangulation process must be incorporated as a particular kind of surface feature type (Environmental Systems Research Institute, Inc., 1998). In this case we use the option 'Hard Clip' so that each bathymetric line is used as a reference point of interpolation. Meanwhile, the 'Clip' polygon command means that all areas outside the polygon are marked as being outside the zone of interpolation for the model. Analytic operations will ignore these areas (Environmental Systems Research Institute, Inc., 1998) (Fig. A.13A-D in Appendix A).

Calculating the Area and Volume Statistics

Once a TIN file has been created, one can calculate the area and volume statistics for a given elevation. First, one activates the ArcView extension ‘3D Analyst’, if not already activated, which supports three primary data types for modeling three-dimensional features: grids, TINs, and shapefiles (2D and 3D) (Environmental Systems Research Institute, Inc., 1998). One selects ‘3D Analyst’ from the list of available ArcView extensions and from the ‘3D Analyst’ scrollbar selects ‘Surface Analysis’ and then ‘Area and Volume.’ Afterwards, a new view will appear on the display called “Area and Volume Statistics” (Fig. A.14 in Appendix A). The new “Area and Volume Statistics” view allows one to calculate area and volume statistics for a surface above or below a reference plane at a specified height, i.e. elevation. Surface area is measured along the slope of a surface, taking height into consideration. The area calculated will always be greater than simply using the two-dimensional planimetric extent of the model. When compared to planimetric area, surface area provides information about surface roughness. The larger the difference between the two values, the rougher the surface. Volume calculates the cubic space between a TIN surface and a horizontal plane located at any specific elevation. The volume can be determined either above or below the plane (Environmental Systems Research Institute, Inc., 1998).

The ‘Area and Volume Statistics’ view has an empty box next to ‘Input surface’ where one selects the TIN file of interest. Next, one enters the elevation of interest for the calculation in an empty box next to ‘Height of plane’ and under ‘Reference parameters’. The user needs to specify whether the calculation statistic will be made above or below the elevation plane. Finally, one clicks on the ‘Calculate statistics’ button under ‘Output statistics’ to obtain the calculation statistics for 2D area (planimetric area), surface area (3D area), and volume. The data can then be saved in a specified location with a specified file name by placing a check mark in the box next to ‘Save/append statistics to text file.’ When calculating the volume and surface areas, one needs to make sure that the display units are the same as the units being calculated in the attribute table or else inaccurate calculations will be made, i.e. all units in meters or all units in feet.

The “Area and Volume Statistics” view also contains an option called vertical exaggeration or Z-factor. The Vertical exaggeration, Z-factor, refers to increasing or decreasing the height in a scene. It is common to increase height of terrain models where the horizontal extent is much larger than the vertical extent. The value specified for exaggeration will multiply heights for all themes (Environmental Systems Research Institute, Inc., 1998). In this particular case, the Z-factor was left blank, as the units of measure in the view and dataset were the same. Had the units been different, one could use the Z-factor to adjust the calculations to compensate. For instance, if the attribute table data were in feet, one could adjust the Z-factor to 0.3048 (1 meter = 0.3048 feet) in order to compensate for the display units being in meters.

Results

In general terms, the results are an efficient method that can be applied in many hydrological or eco-engineering studies in order to examine potential environmental effects using many different socioeconomic scenarios. This is important so that the 'best' approach in terms of environmentally sound construction takes place in the conceptual phases of planning, rather than relying on mitigation measures thereafter.

More specifically, the results of our case study are two different impoundment scenarios, not including the baseline scenario of no impoundment, for the Salton Sea. Figure A.15 in Appendix A illustrates impoundment scenario 3 for the Salton Sea in which the inner (southern) overflow impoundment will be hypersaline while the outer (northern) impoundment will remain a marine lake. The new bathymetry data for each impoundment scenario were incorporated into the simulation modeling projections (Tables B.1 through B.4 in Appendix B). The results of the simulation model projections are then entered into the attribute table for a given scenario providing a spatial and temporal context. The newly created bathymetry data, i.e. GIS calculated elevation:surface area:volume relationships, were plotted and compared to the bathymetric results of a previous study prepared for the U.S. Bureau of Reclamation by Weghorst (2001) (Tables B.5 through B.8 & Figs. A.16 through A.19 in the Appendices).

Discussion and Conclusions

Key differences between the two modified Salton Sea scenarios can be observed. In scenario 2 (Table B.1 in Appendix B), the south impoundment has a larger volume (5,206,102 acre-feet) than the north impoundment (4,144,717 acre-feet). Conversely, in scenario 2 (Table B.2 in Appendix B) the north impoundment has a larger volume

(6,338,009 acre-feet) versus the south impoundment (3,012,855 acre-feet). In scenario 3 (Table B.3 in Appendix B), the south impoundment has a larger surface area (141,287 acres) versus the north impoundment (93,543 acres). Contrarily, in scenario 3 (Table B.4 in Appendix B), the north impoundment has a larger surface area (129,811 acres) than the south impoundment (105,018).

The GIS calculated elevation:surface area:volume relationships were similar to the results of a previous study prepared for the U.S. Bureau of Reclamation by Weghorst (2001). It is important to keep in mind that the datasets used in the comparison were not identical in terms of estimated bathymetrical data for the Salton Sea. In essence, the USBR data set was based on revised 1995 Hydrographic GPS survey data and included influences due to shoreline levees no included in the 1955 survey (Weghorst, 2001). As a result, the elevation at –220 (fasl) was estimated at 250,082 acres with a volume of 9,318,560 acre-feet. However, the bathymetry shapefile for the Salton Sea obtained from the Redlands Institute, University of Redlands (2004) showed an estimated 234,830 acres with a volume of 9,350,905 acre-feet for the elevation at –220 (fasl). The two modified Salton Sea scenarios exhibit some differences, albeit small ones, when compared to the USBR data. First, when comparing TIN calculated and USBR volumes and surface areas at given elevations, percent differences were variable with an increasing trend at lower (deeper) elevations (Tables B.5 through B.8 & Figs. A.16 through A.19 in Appendices). Second, the TIN calculated volumes and surface areas for Scenarios 2 and 3 were less than 1.1 percent and 6.1 percent different (respectively) from the overall total USBR volumes and surface areas (Tables B.5 through B.8 & Figs.

A.16 through A.19 in Appendices). Overall, the differences are minor and in terms of our study the greater differences at lower elevations should not be much of a factor, as the Salton Sea should not decrease to such extremes over the projection period.

Currently, due to GIS and STELLA modeling software incompatibilities, we use the model output and manually transfer the results into the GIS to obtain a display of the results in a spatial and temporal context. However, in the future and now that the scenarios have been constructed, they could be linked to a software compatible simulation model directly, e.g. loose coupling, which is when data are transferred between models and GIS, and each has a separate database management capability and system (McKinney and Cai, 2002).

CHAPTER III

A STRATEGY FOR MODELING SALTON SEA BASIN FUTURE CLIMATE SCENARIOS BASED ON RELATIONSHIPS BETWEEN EVAPOTRANSPIRATION AND PRECIPITATION

Evapotranspiration (Eto) is one of the less understood components of the hydrologic cycle (Naoum and Tsanis, 2003) but is a major component in terrestrial water balance models (Castañeda and Rao, 2005). Ecological simulation models often require projections of daily Eto, as well as daily precipitation, represented as stochastic variables, which control important ecological processes that are being simulated. The objective of this paper is to develop an appropriate methodology to generate Eto and precipitation as driving variables in a simulation model based on historical Eto and precipitation data within the Salton Sea Basin.

One study, Naoum and Tsanis (2003), revealed that temperature was the most influential factor in estimating reference Eto followed by wind speed. Reference evapotranspiration represents the effect of the climate on the Eto process (Naoum and Tsanis, 2003). Basically, Eto is the sum of the volume of water used by vegetation (transpired), evaporated from the soil and the intercepted precipitation on vegetation (Singh, 1988; Naoum and Tsanis, 2003). The difference between evaporation and transpiration is that the latter consists of the vaporization of liquid water contained in plant tissues and the vapor removal to the atmosphere while evaporation occurs at the topsoil if the water is available (Allen et al., 1998; Naoum and Tsanis, 2003).

The effect of a precipitation event or subsequent events on Eto levels in a desert environment on a daily temporal scale was explored herein. One source, Scott et al. (1997) observed that the effect of a precipitation event in the Sahara desert environment had a negative effect on evaporation, but the effect rapidly decreased within the first day. Notably, the timescale of soil moisture storage determines the timescale of the Eto persistence and thus the timescale of humidity persistence in the near-surface atmosphere. The Sahara Desert, much like the Colorado Desert surrounding the Salton Sea, is characterized by bare soils and large amounts of available energy allowing for any rainfall to quickly return to the atmosphere (Scott et al., 1997).

Background Information

Lower Colorado River Basin

The Colorado River, having its headwaters in Wyoming and discharging into the Gulf of Calfiornia, has a drainage basin of about 246,700 square miles within the United States of America (White and Garrett, 1987; Owen-Joyce and Raymond, 1996). Millions of people and many states depend on the Colorado River to support local economies, provide habitat, and most importantly, provide drinking water. Various social issues and uses have caused the river's resources to become overextended, while drought and growing populations further complicate the problems. During an average year, the river only produces 15 million acre-feet (maf) of water and allocations are set at 16.5 maf annually. The average flow for the past 30 years has only reached 12 maf of water in the river. It is projected that in the next 30 years many of the states will start to experience shortages, beginning with Arizona (McKinnon, 2003). Environmental concerns have already arisen for Colorado River native fish populations, the Colorado River Delta, and the Salton Sea with more than 75 percent of its inflows coming from agricultural field drainage irrigated with Colorado River water (Cohen et al., 1999).

Salton Sea Basin

The Salton Sea is located in the Colorado Desert in southeastern California (33º 15' N, 116º W) approximately 35 miles (56 km) north of the U.S.-Mexico border (Cohen and Hyun, 2006). The Salton Sea watershed spans some 8,360 square miles (21,700 km^2) and extends from San Bernardino County through Riverside and Imperial counties and into the Mexicali Valley, in Baja California, Mexico (Cohen et al., 1999). Lying in one of the most arid regions of North America, maximum temperatures around the Salton Sea may exceed 100º F (38º C) more than 110 days each year (Figs. A.20 & A.21 in Appendix A); while temperatures seldom drop below freezing. Annual precipitation in the region averages less than 3 inches (7.6 cm), while net evaporation rates from the sea's surface and Eto exceed 66 inches (175 cm) annually (Fig. A.22 in Appendix A) (Munevar, 2006; Cohen and Hyun, 2006). Notably, a similar climate can be found in Northern Africa in areas of the dry, subtropical Sahara Desert.

Methods

The acquisition of climate data was accomplished using the station-based method, thereby utilizing Eto and precipitation daily estimates within each month at point locations for a 25-year period, from 1980 - 2004, corresponding to meteorological stations in the study area (Naoum and Tsanis, 2003). Eto and precipitation data from two weather stations on the north end of the Salton Sea (i.e. Indio and Thermal) were averaged, as were data from two weather stations on the south end of the sea (i.e. Brawley and Calipatria) and then both the north and south datasets were averaged (Fig. A.23 and Table B.9 in Appendix B).

The averaging of the weather station datasets in the fore-mentioned manner is an accepted practice. For instance, Voinov et al. (1998) developed the Everglades Landscape Model and based simulated rainfall on precipitation data interpolated over nine weather stations. Another study, Bhuyan et al. (2003) averaged rainfall data for two weather stations having a north-south orientation within a sub-watershed to "reasonably" represent the average rainfall over the entire sub-watershed. More recently, the Salton Sea Ecosystem Restoration Program (2006) stated that precipitation on the Salton Sea water surface is best estimated by an average of rainfall recorded from the stations closest to the Salton Sea due to the size of the sea. For their purposes, annual rainfall data were obtained from the Western Regional Climate Center for both Brawley and Mecca weather stations and then averaged to approximate rainfall volumes that fell on the Salton Sea surface. After compiling the historic precipitation and Eto data, thirty-four probability distributions (Table B.10 in Appendix B) were fit to the days of each month in the historic precipitation and Eto datasets. Monthly distributions were used to preserve seasonality when modeling future climate scenarios, while not solely restricting future climate scenarios to historical values. Additionally, it was hypothesized that different durations of precipitation events would have different, most likely downward, effects on Eto. Therefore, individual categories representing single versus multiple precipitation events and corresponding volumes were sorted into subset datasets, along with their respective Eto volumes. Next, a curve fitting program, EasyFit Version 1.3, from MathWave© Technologies (2006) was used for curve-fitting analyses. The theoretical distribution that provided the "best" fit for each month was determined based on the Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) tests of statistical significance, as well as a visual comparison of the fitted curves to the historic frequency distribution.

Precipitation Events and Eto Levels

For the purpose of the present study, one weather station was chosen for the analysis of the relationships between Eto and precipitation, specifically, the Brawley-Calipatria averaged Eto and precipitation datasets consisting of daily data from 1982-2004. Two procedures were undertaken to ascertain the effects of precipitation events on Eto levels. The lag-times between Eto levels before precipitation events as compared to during and after precipitation events were also examined. The first step in the analyses involved converting the historic precipitation and Eto data to categorical variables. The precipitation data were converted to a nominal categorical variable, '*Rain Event*' denoting days lacking a precipitation event with a 0 and a 1 for days where a precipitation event was present. The Eto data were converted to a nominal categorical variable, '$Eto \leq 0.21$' denoting days with an Eto more than 0.21 inches with a 0 and days having an Eto equal to or less than 0.21 inches with a 1. Next a comparison was made between the proportions of days with precipitation events and the proportions of days with Eto levels equal to or less than 0.21 inches.

Next a linear regression was performed using the variables '*Rain Event*' and '*Eto*', representing the historic Eto dataset. The linear regression showed a negative correlation, -0.14107 ($P<0.05$), between precipitation events and Eto levels. However, correlation is based on continuous data, and precipitation is a mixture between discrete and continuous distributions. Since the data being analyzed are time series data, autocorrelation exists between the observations, thereby violating one of the assumptions of linear regression, i.e. independence of the observations. Therefore, a statistical procedure other than linear regression was needed in order to accurately assess the degree of correlation between precipitation and Eto. Normally, time series analysis could be utilized when comparing two variables over time; but this was not the case in the present circumstance.

Because the Salton Sea is located in an arid region, many of the daily precipitation values are zeros, 90 percent or more in many cases. As a result of many days without precipitation, the precipitation data exhibited a mixed distribution with a high number of observations having a value of zero and a continuous distribution when there actually were precipitation events. Traditional time series analysis to account for autocorrelation between observations does not handle datasets with such high zero counts. Therefore, to determine the relationships among precipitation events and between precipitation events and Eto levels, binomial and multinomial logistic regression models were utilized (Table B.11 in Appendix B). The variables used in the binomial and multinomial logistic regression models are described in Table B.12 in Appendix B.

Precipitation Event Versus Subsequent Precipitation Events

One of the tasks in this study was to determine the probability of a precipitation event given the absence of precipitation the day before versus precipitation of a given volume the day before and the probability of the absence or presence of a precipitation event of a given volume occurring thereafter. As such, the historic precipitation data were converted to an ordinal categorical variable termed "*PrcpAmt*". A query to determine how many precipitation events of a given volume (value) followed another precipitation event of a given volume was performed. The number of observations meeting the rules of a given query was entered into a table so that the previous day's precipitation volume was located in rows with the current day's precipitation volume in columns, i.e. the rules of the query. The conditional estimated probabilities of precipitation events were then calculated by dividing the number of observations meeting a given query's definition by its row total, i.e. total possible observations.

Results

A comparison of the averaged weather station datasets versus the historic individual weather station datasets was made for both precipitation (Figs. A.24 through A.29 and Table B.13 in the Appendices) and Eto (Figs. A.30 through A.33 and Table B.14 in the Appendices). The averaged monthly dataset preserved seasonality for both precipitation and Eto as illustrated in the figures.

Notably, for the months of February, March, and April (Fig. A.25 in Appendix A) the average monthly precipitation volume was lower than the actual weather station historic data. This occurred for two reasons: 1) the disparity in the number of observations between the two weather station datasets and the average resulting in the largest number of observations between the two, and 2) the concomitant decrease in values due to averaging, e.g. one weather station having a higher precipitation volume on a given day and the other a much lower value for the respective day. The missing data in the Brawley-Calipatria dataset (Fig. A.26 in Appendix A) required the replacement of missing data with Thermal-Indio weather station values, and in such cases, often with a volume of 0 due to the high frequency of days without precipitation events.

Distributions of Precipitation Events and Eto Levels

Graphs of the curve fitting results based on the historic frequency distributions for both precipitation and Eto provided a visual aid for determining which theoretic probability distribution gave the "best" fit (Figs. A.34 through A.45 and Figs. A.46 through A.57, respectively, in Appendix A). The curve providing the "best" fit and associated levels of significance (P-value) for the Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) test statistics were recorded for each weather station dataset as well as the TIBC averaged dataset (Tables B.15 through B.26 (precipitation) and Tables B.27 through B.38 (Eto) in Appendix B). The results of the two test statistics differed at times, i.e., listing two different curves as providing the "best" fit. In the fore-mentioned situation, a final decision pertaining to the "best" fit was made based on a visual assessment of the figures. A summary of the overall curve fitting results can be found in Tables B.39 and B.40 in Appendix B.

Precipitation Events and Eto Levels

The importance of using monthly data instead of annual data for the Salton Sea Basin can be found in the Appendices, i.e., Figs. A.58 through A.78 and Tables B.41 through B.64. Further, the two models: (1) $(Logit\ Y_{1,\ldots\ldots\ldots.12})\ Month = Constant + X_1\ Prcp$, and (2) $(Logit\ Y_{1,\ldots\ldots\ldots.12})\ Month = Constant + X_1\ Eto$, established that some months were significantly different than others concerning the amounts of precipitation and Eto, respectively (Tables B.65 & B.66 in Appendix B). The relationships between the duration of precipitation events (‘CatEvent’) on the volume of precipitation (‘PrcpAmt’ and ‘CatVol’), and also on Eto volumes can be seen in the Appendices, specifically Figs. A.66 through A.78 and Tables B.67 through B.78. A plot of the precipitation and Eto observations, percentage or percentage of observations of a given magnitude, respectively, by month was also made (Fig. A.68 in Appendix A).

The negative relationship between precipitation and Eto was tested statistically using two multinomial logistic regression models and one binomial logistic regression model, respectively: (3) $(Logit\ Y_{0,\ldots 4})\ PrcpAmt = Constant + X_1\ Eto$, (4) $(Logit\ Y_{0,\ldots.5})\ CatEvent = Constant + X_1\ Eto$, and (5) $(Logit\ Y_{0,1})\ RainEvent = Constant + X_1\ Eto$. The first model resulted in negative coefficients ($P<0.05$) for all four categories of ‘PrcpAmt’ and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.1050 (Table B.79 in Appendix B). A likelihood-ratio test for independent variables resulted in a chi^2 of 382.6 and P > chi^2 of 0.000. Similarly, the second model (4) resulted in negative coefficients ($P<0.05$), with an increasing trend, for all five categories of 'CatEvent' and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.1240 (Table B.80 in Appendix B). Also, a likelihood-ratio test for independent variables resulted in a chi^2 of 439.9 and Prob> chi^2 of 0.000. The binomial logistic regression model (5) resulted in a statistically significant (P<0.05) and negative coefficient for the variable Eto and an overall Pseudo R^2 of 0.1312 (Table B.81 in Appendix B).

The relationship between the volume of a single precipitation event and subsequent precipitation event volumes and associated changes in Eto was tested statistically using the multinomial logistic regression model: (6) *(Logit $Y_{0,\ldots4}$)* *CatVol = Constant + X_1 Eto*. The model resulted in negative coefficients for all four categories of 'CatVol' and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.1231 (Table B.82 in Appendix B). The categories 1, 2, and 4 of the nominal categorical variable 'CatVol' were significant (P<0.05). Also, a likelihood-ratio test for independent variables resulted in a chi^2 of 433.236 and P > chi^2 of 0.000. Similarly, the relationship between different precipitation volumes and associated changes in Eto before a precipitation event and the day of a precipitation event was tested statistically using the multinomial logistic regression model: (7) *(Logit $Y_{0,..3}$) EtoFirst = Constant + X_1 PrcpAmt*. The model resulted in statistically significant (P<0.05) positive coefficients for categories 1, 2, and 3 of 'EtoFirst' (using category 0 as the base outcome) and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.4226 (Table B.83 in Appendix B). Also, a likelihood-ratio test for independent variables resulted in a chi^2 of 1026.596 and P > chi^2 of 0.000. Another model, (8) *(Logit $Y_{0,\ldots4}$) EtoFirst = Constant + X_1 Eto*, showed that the categories of 1, 2, and 3 of the dependent nominal categorical variable 'EtoFirst' were less than the base outcome, as all had negative and significant ($P<0.05$) coefficients (Table B.84 in Appendix B).

The relationship between Eto the day of a precipitation event (or the first day in a series of events) and the day after the event (or series of events) was tested statistically using the multinomial logistic regression models: (9) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1\ PrcpAmt + X_2\ CatEvent$, (10) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1 Eto$, (11) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1\ PrcpAmt + X_2\ CatVol + X_3\ CatEvent + X_4\ Month$, (12) $(Logit\ Y_{0,.2})\ Prcponafter = Constant + X_1\ Eto$, and (13) $(Logit\ Y_{0,.2})\ Prcponafter = Constant + X_1\ EtoPerCh$. The first model (9) resulted in positive coefficients ($P<0.05$) for categories 1, 2, and 3 of 'Etolev2', for both independent variables, and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.4942 (Table B.85 in Appendix B). Also, a likelihood-ratio test for independent variables resulted in a chi^2 of 82.876 for 'PrcpAmt' and 317.128 for 'CatEvent' and both had a P > chi^2 of 0.000. Another multinomial logistic regression model, (10) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1 Eto$, showed that 'Etolev2' categories 1, 2, and 3 all had negative coefficients, although category 1 was not significant, $P>0.05$ (Table B.86 in Appendix B). Two additional variables to measure the effect of month (indicator variable 'Month') and whether a subsequent precipitation event occurred and if so comparing the magnitude of the second with the first ('CatVol'), were included in another model: (11) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1\ PrcpAmt + X_2\ CatVol + X_3\ CatEvent + X_4\ Month$. The new model resulted in some negative coefficients for the independent variables of 'CatVol' and 'Month' but not

'PrcpAmt' and 'CatEvent' and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.4952 (Table B.87 in Appendix B). The independent variables 'CatVol' and 'Month' were not significant ($P>0.05$) for any of the three categories of the dependent nominal categorical variable 'Etolev2'. Also, a likelihood-ratio test for independent variables resulted in a chi^2 of 1.541 for 'CatVol' and 0.906 for 'Month' and P > chi^2 of 0.673 and 0.824, respectively. Models 12 and 13 measuring the relationship between precipitation and Eto and the percent change in Eto the day of the event, as compared to after the event, both had statistically significant ($P<0.05$) and negative coefficients and a Pseudo R^2 of 0.0614 and 0.0242, respectively (Tables B.88 and B.89 in Appendix B).

The relationship between Eto the day before a precipitation event (or sequence of precipitation events) and the day after (or after the last precipitation event in the sequence) was tested statistically using the multinomial logistic regression models: (14) *(Logit $Y_{0,.2}$) Prcpbefafter = Constant + X_1 Eto*, and (15) *(Logit $Y_{0,.2}$) Prcpbefafter = Constant + X_1 EtoPerCh*. The model (14) measuring the relationship between precipitation and Eto before the day of the event, as compared to the day after the event, had statistically significant ($P<0.05$) and negative coefficients and a Pseudo R^2 of 0.0377; while the model (15) measuring the percent change in Eto had a Pseudo R^2 of 0.0155 with positive coefficients for the independent variables. Also, category 2 of the dependent nominal categorical variable '*Prcpbefafter*' was statistically significant ($P<0.05$) whereas category 1 was not ($P=0.802$) (Tables B.90 and B.91 in Appendix B).

The general relationship between Eto the day of the first precipitation event (or the first day in a series of events) compared to days without precipitation (or days having precipitation events that are not the first day in the series of events) was tested statistically using the binomial logistic regression model: (16) *(Logit $Y_{0,1}$) PrcpOn = Constant + X_1 EtoPerCh*. The model resulted in a statistically significant ($P<0.05$) negative coefficient and had a Prob > chi^2 of 0.0000 and Pseudo R^2 of 0.0150 (Table B.92 in Appendix B).

Precipitation Event Versus Subsequent Precipitation Events

The analysis of single versus subsequent precipitation events resulted in a table (Table B.69 in Appendix B) showing the probability of a given precipitation volume for a second consecutive precipitation event based on the precipitation volume of the first precipitation event. The high zero count or lack of precipitation events in the dataset (96.3 percent) was made clear in the table. The previous day's precipitation volume (first event) is located in the rows with the current day's precipitation (second event) in columns. As described earlier, conditional estimated probabilities of precipitation events of several different magnitudes were found by dividing a number, representing the number of observations fitting the rules of a given query, in the table by its row total. For example, given that there was between 0.1 and 0.2 inches of precipitation yesterday, the probability that another precipitation event producing between 0.1 and 0.2 inches will occur today is estimated to be $3 \div 72$ or 0.041667 percent.

Discussion and Conclusions

The averaging of the weather station data for both precipitation and Eto provided a complete dataset for a 25-year period (1980-2004) for the Salton Sea area. Although the pattern of monthly precipitation volumes was preserved when the two separate whether station datasets were averaged, the frequency of precipitation events of a given duration was inflated somewhat. More specifically, the averaging increased the number of consecutive precipitation events when comparing the Brawley-Calipatria dataset, having a maximum of 7 consecutive events (Figs. A.24 and A.58 in Appendix A) and the Thermal-Indio dataset having a maximum of 9 consecutive events with the averaged dataset (TIBC) having a maximum of 10 consecutive events (Tables B.56, B.58, and B.59, respectively, in Appendix B). The frequency of smaller events was inflated as well. For example, precipitation events of five or more days in duration were as follows: Brawley-Calipatria with 7 instances, Thermal-Indio with 13 instances, and the averaged dataset (TIBC) with 36 instances. Similarly, events of 8 days in duration or more were as follows: Brawley-Calipatria with 0 instances, Thermal-Indio with 3 instances, and the averaged dataset (TIBC) with 8 instances. As a result, some months in the averaged TIBC dataset experienced inflated precipitation event durations more than others, e.g., January, September, and December.

In summary, the Brawley-Calipatria weather station dataset statistical relationships, concerning subsequent precipitation events, were implemented and not those based on the averaged dataset. The fore-mentioned strategy was undertaken as a means to avoid the inflated frequencies of multiple precipitation events being incorporated into the simulation model.

Distributions of Precipitation Events and Eto Volumes

The curve-fitting exercise resulted in similar distributions providing the "best" fit to the data, however the distribution for the TIBC averaged dataset for days of individual months often varied, more so in the case of Eto than for precipitation (Tables B.39 and B.40 in Appendix B). For example, the most common distribution type providing the "best" fit for both the Brawley-Calipatria and Thermal-Indio Eto datasets was a Wakeby distribution, but the TIBC averaged dataset (average of the two) more closely resembled Wakeby, General Logistic, and General Extreme Value distributions, depending upon the month in question. The most common distribution types providing the "best" fit for both Brawley-Calipatria and Thermal-Indio precipitation monthly datasets were Gamma and Exponential distributions, but the TIBC averaged dataset more often resembled Gamma and Rayleigh distributions. Ideally, different distributions would be incorporated for respective months in any future climate scenario simulation modeling exercise concerning the Salton Sea.

Precipitation Events and Eto Levels

It was hypothesized that precipitation and Eto would generally exhibit a negative relationship in the area surrounding the Salton Sea, i.e., Eto volumes decreasing with precipitation events. Also, the volume and duration of precipitation events would be important factors to consider when exploring any relationship between precipitation and Eto.

The precipitation data in this study demonstrated that the majority of the rainfall occurred during the winter months. Also, months with a higher percentage of precipitation events had a larger percentage of days with low (0.21 or less) evapotranspiration (Fig. A.68 in Appendix A). And like the study by Scott et al. (1997), where the effect of a precipitation event in the Sahara desert environment had a negative effect on evaporation; the results herein indicated that the same was true for Eto in the desert environment around the Salton Sea. However, unlike the results of Scott et al. (1997) that showed the effect of a precipitation event on evaporation rapidly decreasing within the first day, the results of the present study elucidate a more complex relationship.

There are two important variables that play a role in the relationship between precipitation and Eto amounts, namely duration (‘CatEvent’) and volume (‘PrcpAmt’). The results demonstrate that a longer event is more likely to suppress Eto volumes (Table B.74 and Fig. A.73 in the Appendices) and for a longer time period. Likewise, larger precipitation volumes suppress Eto volumes more so than the small precipitation volume events; however, larger precipitation volume events also tend to have a higher proportion of the largest Eto volumes compared to small precipitation events (Table B.78 and Fig. A.78 in Appendix A). Therefore, the variable ‘CatEvent’ would seem to be a better predictor of Eto volumes, and the multinomial logistic regression models support this.

The chances of a decrease in Eto the day of a precipitation event compared to the day before the precipitation event were twice as likely (62 percent) than Eto increasing the day of the precipitation event (31 percent) (Table B.70 in Appendix B). Further, lower precipitation amounts had a slightly higher probability (42 and 43 percent, respectively) for categories 1 and 2 of the ordinal categorical variable ‘PrcpAmt’ versus (35 and 29 percent, respectively) for categories 3 and 4. The probability of Eto more than the day before the precipitation event increased for category 4 of ‘PrcpAmt’ (32 percent) versus (29 percent) for categories 3 and 1, respectively, of the variable ‘EtoFirst’. The overall negative effect of precipitation on Eto levels was supported by both the multinomial and binomial logistic regression models (3, 4, and 5 respectively) in Tables B.79, B.80, and B.81 in Appendix B, respectively, showing statistically significant ($P<0.05$) and negative coefficients for all categories of ‘PrcpAmt’, ‘CatEvent’, and ‘RainEvent’. Compared to days without precipitation events, days with precipitation events had significantly lower Eto volumes. Similarly, all categories of the ordinal categorical variable ‘CatEvent’ measuring duration of precipitation events had statistically significant ($P<0.05$) negative coefficients and showed that the longer the duration of the precipitation event, the larger the decrease in Eto levels, in general (Table B.80 in Appendix B). Also, the Pseudo R^2 was somewhat larger for the variable ‘CatEvent’ versus ‘PrcpAmt’ (0.1240 versus 0.1050, respectively) meaning that the duration of the precipitation event was a slightly better predictor of the decrease in Eto volumes. The nominal categorical variable ‘CatVol’ distinguished between a single or subsequent precipitation event taking into account volume and supported these conclusions based on the multinomial logistic regression model (6) (Table B.82 in Appendix B).

The multinomial logistic regression model (8) with the dependent nominal categorical variable ‘EtoFirst’ measured whether Eto the day of a precipitation event was less than, equal to, or greater than before the precipitation event. The model (8) demonstrated that Eto volumes the day of a precipitation event were significantly less than Eto volumes on days without precipitation (Table B.84 in Appendix B). Further, the plot of the precipitation and Eto observations by month (Fig. A.68 in Appendix A) revealed that months with a higher percentage of rain days also had a higher percentage of days with Eto less than or equal to 0.21 inches. In summary, Eto and precipitation exhibit a negative relationship overall.

When observing recovery time using the nominal categorical variable ‘Etolev2’ (models 9-11 in Tables B.85 through B.87 in Appendix B) measuring whether Eto is the same after a precipitation event (or the last event in the series of events) as during a precipitation event (or the last day of precipitation in the series of events), there was a greater likelihood of Eto increasing the day after the precipitation event or series of events versus decreasing (38 versus 21 percent, respectively). The greater likelihood of Eto increasing the day after the precipitation event (or series of events), versus decreasing, was also the case for events lasting more than one day, e.g. 13 versus 59 percent (respectively) for two-day events (Table B.71 in Appendix B). The recovery time or increase in Eto after the precipitation event was more likely with lower precipitation volumes than for higher precipitation volumes, e.g. 50 percent for category 1 versus 29 percent for category 4 of the dependent variable ‘PrcpAmt’ (Table B.76 in Appendix B). Also, the binomial logistic regression model (16) with the dependent nominal categorical variable ‘PrcpOn’ showed a negative change in Eto on the day of a precipitation event, or first day in a series of events when compared to days without precipitation events (Table B.92 in Appendix B). Moreover, the multinomial logistic regression model (12) with the dependent nominal categorical variable ‘Prcponafter’ showed that compared to days without precipitation, the first day of a precipitation event produced a lower Eto volume (coefficient of -5.842) while days after a precipitation event (or the last day in a series of events) also had a lower Eto volume (coefficient of -4.624) (Table B.88 in Appendix B). Clearly, the first day of the precipitation event had a larger Eto volume than the day after the precipitation event (or series of events) indicating some recovery from the precipitation event. The recovery time of Eto was tested using another multinomial logistic regression model (13) using the same dependent variable ‘Prcponafter’ but with the independent variable ‘EtoPerCh’, measuring the percent change in Eto from one day to the next. The model (13) results showed that when compared to days without precipitation, Eto decreased on the first day of a precipitation event. However, a positive change in Eto the day after the precipitation event (or the last day in a series of events) means Eto increased when compared to days without precipitation events (Table B.89 in Appendix B).

An analysis of the frequency of observations for each category of the variable ‘EtoOne’ showed that Eto the day after a sequence of precipitation events is generally less than the Eto the day before the sequence of precipitation events. In fact, the Eto volume after the precipitation event is less than the Eto volume the day before the first precipitation events 48 and 50 percent of the time for larger precipitation volume events (Table B.77 in Appendix B). Therefore, the frequency that recovery time is within a day of a precipitation event only occurs about 50 percent of the time for larger volume precipitation events.

Finally, the multinomial logistic regression model (14) demonstrated that there is actually less Eto the day before a precipitation event as compared to days without precipitation (Table B.90 in Appendix B). Moreover, compared to days without precipitation there is typically less Eto the day after the precipitation event, or last day in a series of events. The other multinomial logistic regression model (15) reveals a positive increase in Eto before a precipitation event and a positive increase the day after a precipitation event (or series of events) when compared to days without precipitation events (Table B.91 in Appendix B).

Precipitation Event Versus Subsequent Precipitation Events

Based on the complex relationships revealed by the logistic regression models, a methodology to generate Eto and precipitation as driving variables in a simulation model other than using the historical frequency distribution was developed for Eto and precipitation data within the Salton Sea Basin. Basically, the statistical distribution curves were fit to the historical Eto and precipitation data allowing for each day of a simulation to be randomly selected from a theoretic daily precipitation frequency distribution, for a respective month (Fig. 2A). In terms of future climate scenarios, if a rain event happened to be selected, then another daily precipitation duration frequency distribution would be randomly sampled (Fig. 2B). Based on the historical Brawley-Calipatria weather station data, the duration of a precipitation event could range from 1 to 7 days. Therefore, a corresponding precipitation duration frequency distribution would need to be sampled in order to determine the precipitation volume for the precipitation event in question (Fig. 2C). Next, the corresponding Eto volume frequency distribution would be sampled to determine the Eto volume associated with the precipitation event (Fig. 2D).

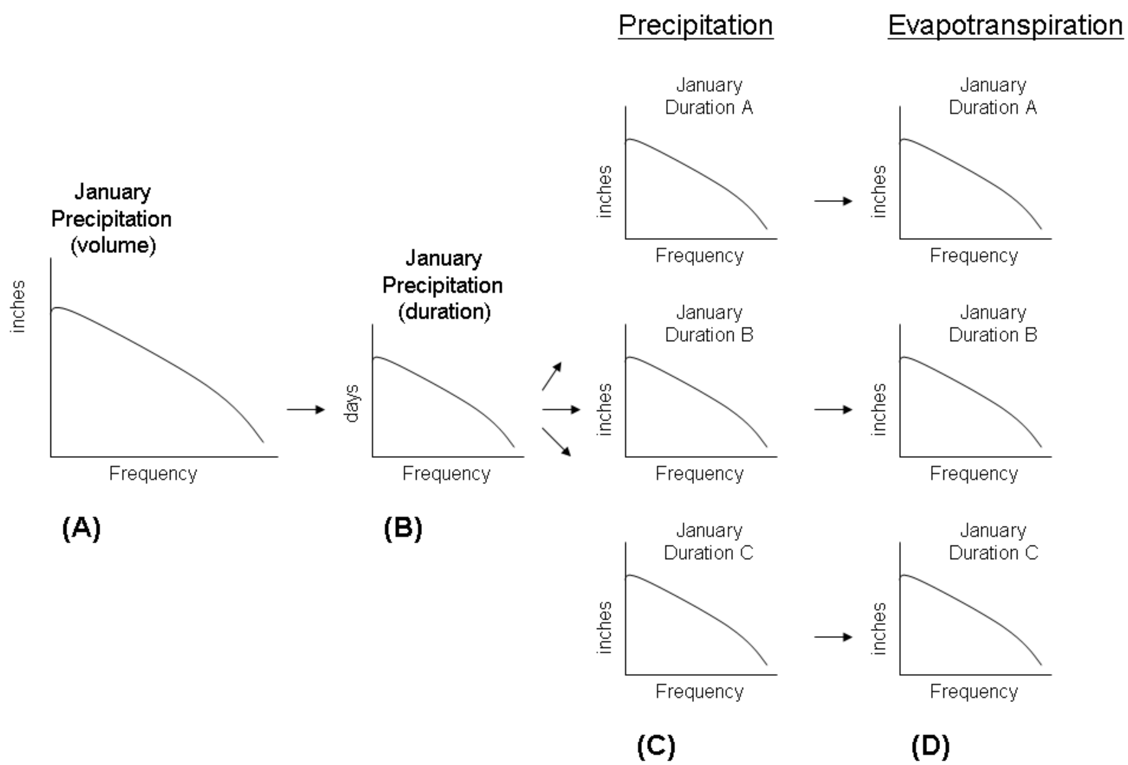

Fig. 2 - Simulation model sampling method for Eto and precipitation.

The results of the logistic regression and curve fitting analyses provided a valuable insight into the dynamics between single versus multiple precipitation events and the interaction between Eto and precipitation in the Salton Sea Basin, both of which are essential to the development of the fore-mentioned future climate scenario methodology. Results show that months with a larger percentage of precipitation events had a larger percentage of days with low Eto. Similar to the Sahara desert study by Scott et al. (1997), the effect of a precipitation event had a negative effect on Eto in the desert environment around the Salton Sea, but elucidated a more complex relationship. The results demonstrate that the longer the duration of the precipitation event, the larger the decrease in Eto volumes, in general, and for a longer period of time. Likewise, larger precipitation volume events suppress Eto volumes more so than the smaller precipitation events. Based on the multinomial logistic regression models, the duration of the precipitation event is a slightly better predictor of Eto volumes. Overall, Eto and precipitation exhibit a negative relationship.

The curve-fitting results for each monthly dataset resulted in similar distributions providing the “best” fit to the data, however the distributions for the averaged monthly TIBC dataset often varied, more so for Eto than precipitation. Therefore, different distributions should be incorporated for respective months when modeling future climate scenarios in the Salton Sea Basin. The overall low Pseudo R^2 values of the multinomial regression models lend support for using this kind of a strategy.

CHAPTER IV

HYDROLOGIC COMPONENTS AND POLICY SCENARIOS OF THE MASS-BALANCE SALTON SEA SIMULATION MODEL

Divided by an international border, the Imperial-Mexicali Valleys (IMVs) are linked by shared history, natural resources, culture and economy. This region is experiencing changes driven by policy makers both within and outside the IMVs. The largest external decision, the Colorado River Quantification Settlement Agreement (QSA) of 2003, opens the door to a laboratory for studying the consequences of a massive transfer of agricultural water to municipal users.

Two irrigation districts, two urban water agencies and the State of California have agreed to a 75-year transfer of more than 30 million acre-feet of Colorado River water from agricultural to urban use. The Imperial Irrigation District (IID)-San Diego Water Conservation Transfer Agreement, dated April 1998, provides that the IID contract with Imperial Valley (IV) landowners to undertake on-farm water conservation efforts to reduce the demand for Colorado River water. The IID then transfers the conserved water to the San Diego County Water Authority (SDCWA) in exchange for monetary payments (Rea & Parker Research, 2002). A proposal to line the All American Canal, supplied with water diverted from the Colorado River, is intended to reduce the volume of water that must be obtained from IV agriculturalists via the fallowing of farmland to try and meet growing San Diego water demands. However, eliminating seepage from the All American Canal reduces groundwater recharge to aquifers used by Mexican farmers.

Although Imperial Valley (IV) farmers will be compensated for water conservation and land fallowing, the economic, environmental and social consequences are unclear. Farmers who fallow will likely cause a greater impact on local businesses and government than those farmers choosing on-field water conservation. Reduced agricultural water use results in a lower volume of water entering the Salton Sea which, in turn, will impact the population dynamics of fish and avian species at the sea.

Municipal wastewater discharged into the New River by Mexicali, Mexico is also an important source of inflow to the Salton Sea that will be reduced by plans to reclaim the wastewater for various uses, including water for cooling purposes at new power plants in Mexicali. SEMPRA Energy and Bechtel-Intergen have each constructed a power plant in Mexicali, MX. Together, the two plants utilize about 35% of Mexicali's wastewater and approximately 10% of the New River flow (Kamp, 2001). The power plants use water that previously was destined to flow down the New River, eventually to the Salton Sea. Mexico has also been pursuing construction of projects to improve the collection and treatment of wastewater in Mexicali (U.S. Department of the Interior, 2003). As implicated in the Salton Sea Ecosystem Restoration Program (2006), the reduction of flows and salt load in the New River from power plants and wastewater treatment may act as a double edged sword as vital freshwater flow to the Salton Sea is reduced.

The New River provides vital freshwater inflow to the Salton Sea, but it is considered to be the most polluted waterway in the nation (McClurg, 1994). In early 1997 a concerned local organization named Desert Wildlife Unlimited looked for a solution for the New River pollution problem. Desert Wildlife Unlimited worked with local, state, and federal agencies to obtain grant monies, as well as permits and constructed two wetlands (New River Wetlands Project, 2000). Provided there is sufficient federal funding, there could be as many as 35 more wetlands constructed (Yniguez, 2002).

A full-fledged restoration program is being considered for the Salton Sea that would involve funding a project to produce a sea with a reduced surface area or separate impoundments. But this approach may lead to increases in windblown dust from the dry lakebed that will contribute to an air basin already designated as a federal non-attainment area for particulate emissions. Another method proposed to decrease the salinity of the Salton Sea is brine extraction using solar evaporation ponds. It has been estimated that a salinity control system would need to remove 4 million tons of salt year^{-1} (USBR, 2003). Approximately 60,000 acre-feet of brine would need to be removed year^{-1}, depending upon the salinity of the sea, in order to remove 4 million tons of salt year^{-1}.

A complex interplay of water-related issues must be accounted for if planners and residents of the IMVs are to make sound socioeconomic and environmental policy decisions. Both the U.S. portion of the Delta (the Salton Sea and its environs) and the Mexican portion of the Delta (part of the same ecosystem) offer excellent opportunities to experiment with the management of man-made systems to rehabilitate damaged water resources (Salton Sea Authority - Salton Sea Restoration Project, 2001g). Modeling has been employed in previous studies, but only on a limited basis in terms of a temporal scale able to address seasonality and a large spatial scale encompassing both the Salton Sea and Lower Colorado River Basin, including the Mexican portion.

Background Information

A Bureau of Reclamation spreadsheet-based mass-balance and water budget accounting model, the Salton Sea Accounting Model (Weghorst, 2001), was used in the Draft Environmental Impact Statement (DEIS) prepared by Tetra Tech, Inc. (2000) to predict the range of future effects of several water policy scenarios on salinity, elevation, and surface area of the sea. Similar to the present study, the future water policies included reduced future inflows, brine extraction and dike impoundments within the sea. A review of the Salton Sea Accounting Model by the Pacific Institute for Studies in Development, Environment, and Security (2000) found some inconsistent and speculative assumptions of the water balance accounting model. The implication was that the elevation and salinity projections included in the DEIS were flawed. The effect of the DEIS' inaccurate models is to overstate the alternatives' efficacy" (Pacific Institute for Studies in Development, Environment, and Security, 2000).

Several other models were developed to address site-specific alternatives for maintaining the Salton Sea. Two hydrodynamic models, RMA-2 and RMA-10, both formulated for the finite element solution method, were applied to simulate the circulation in the sea. This was done to quantify the effects that diked impoundments would have on the sea's circulation, and to better understand the sea's circulation via a field monitoring program (Cook, Huston, Orlob, King, and Schladow, 1998). Another study conducted a couple of water quality simulations for the –240' and –245' southern impoundments with the BATHTUB model (Walker, 1996; Anderson, 2002). The BATHTUB model uses a series of empirical sub-models to predict the annual nutrient budgets and productivity levels in the water body, that predicted mean annual water quality in two proposed impoundment configurations (Anderson, 2002). A UC Davis hydrodynamic model of the Salton Sea was used to estimate the effects of changes in sea elevation. But they themselves pointed out that further modeling may be conducted as the need arises or as the alternatives are further refined (Tetra Tech, Inc., 2000).

There is a recognized need for integrated (physical, biological, social) models (Groffman and Likens, 1994) but relatively few truly integrated quantitative models exist (Carpenter et al., 1999), and none currently exist for the Lower Colorado River Basin, with regard to the Salton Sea. A more credible approach would be to address the Salton Sea in the context of a complex agricultural-ecological system, where both natural factors such as climate and elevation and anthropogenic factors such as land use impact the sea. The Salton Sea is a component of a larger, regional ecosystem and its restoration must be compatible with longer-term and broader efforts for restoring the Colorado River delta and upper Gulf of California eco-region (Cohen, Glenn, and Morrison, 1999).

A quantitative, simulation model was developed to simulate the hydrologic system that underlies our broader modeling of the socioeconomic and environmental future of the IMVs. Alternative future scenarios were defined and used to explore the hydrologic and environmental implications of variations in future Colorado River flows, climate change, and water-related policy decisions. The results of a suite of simulations, made assuming that the sea is not impounded in small sub-seas, suggest that the salinity of the Salton Sea is most likely to continue increasing. If this is the case, and if restoration of the Salton Sea continues to be a high priority, then the model results suggest that more aggressive water conservation methods or a much smaller sea will be required. More aggressive water conservation will lead to greater socioeconomic concerns, while a smaller sea will increase concerns regarding windblown dust from the exposed lakebed.

In this chapter it is demonstrates how an integrated systems modeling approach combined with a GIS can be used for simulating water quality and quantity management policies on a watershed and localized scale. The first objective of this research was to develop a stochastic simulation model representing both water flow in the Lower Colorado River Basin (LCRB), i.e., water volume and quantity of Total Dissolved Salts (TDS) and Phosphorus (P) in and entering the Salton Sea, respectively, and the population dynamics of selected fish and avian species at the sea. The second objective was to evaluate the model based on its ability to simulate historic trends in water volume and quantity of TDS and P in and entering the Salton Sea, respectively, and population dynamics of selected fish and avian species at the sea. A third objective was to use the model to simulate the effect on water volume and quantity of TDS and P in and entering the Salton Sea, respectively, and population dynamics of selected fish and avian species at the sea, as a result of selected water management scenarios in the LCRB, including: (a) lining the All American Canal with concrete and fallowing farmland in the IV, (b) operating the newly constructed power plants, (c) increasing the number of wetlands in the New River Wetlands Project, (d) extracting brine from the Salton Sea, and (e) dividing the sea into north and south impoundments, and (f) additional wastewater recycling in Mexicali to meet population growth related water demands.

Methods

The Salton Sea model is a stochastic simulation model representing water flow in the LCRB as it enters the Salton Sea and Colorado River Delta and subsequently flows, intermittently, to the Gulf of California (Figs. A.79 and A.80 in Appendix A). The model specifically accounts for the water volume and water quality in the Salton Sea (Fig. A.81 in Appendix A) and is formulated as a compartment model based on difference equations with a daily time step using STELLA® 8.0 software (High Performance Systems, Inc., Lime, New Hampshire, U.S.A.).

The model is comprised of groups of sub-models representing the dynamics of the following: (I) water volume, (II) water quality, (III) the population dynamics of selected fish species in, and (IV) avian species around the Salton Sea. More specifically, the model consists of 11 main sub-models representing the dynamics of: (1) Lower Colorado River Basin, (2) Salton Sea Water Volume, (3) Salton Sea Evapotranspiration, (4) Salton Sea Precipitation, (5) Salton Sea TDS mass fluxes, (6) Salton Sea Water Balance, (7) Salton Sea River Inflows, (8) Salton Sea Exposed Sea Bottom, (9) Agricultural Sector, (10) Human Population Growth, and (11) Salton Sea Ecology. The Salton Sea Ecology Sub-model, the focus of Chapter V, determines the condition of the sea based on avian and fish components that are driven on relationships to sea salinity and phosphorous levels.

Lower Colorado River Basin Sub-model

The Lower Colorado River Basin Sub-model simulates rates of water flow and respective loads of TDS and P mass through the water impoundment structures (i.e., dams), rivers, and canals in the region (Fig. A.81A in Appendix A). Water (in acre-feet/day) enters the system via three driving variables, namely the Colorado River (based on Palo Verde Dam outflow), the Gila River (near Dome, Arizona), and the Whitewater River (near Mecca, California) is based on daily historic flows at United States Geological Survey (USGS) gage stations #09429100, #09520500, and #10259540, respectively, over the period from 1980 through 2004. The river flows are calibrated and validated based on respective USGS gage station flow data recorded over the 15-year period from 1980 - 1994 and validated from 1995 - 2004 at 8 locations (station #10259540 on the Whitewater River, stations #10255550 and #10254970 on the New River, station# 10254730 on the Alamo River, station #10254050 on the Coachella Canal, and stations #09429100, #09429500, and #09429600 on the Colorado River). It should be noted that the USGS gage stations may have some inherent error, perhaps an estimated 10-15 percent (Cohen and Henges-Jeck, 2001).

Subsequent Colorado River flows and diversions downstream are controlled by variables that are dependant upon the Colorado River flow at a specific point of water diversion. More specifically, formulas were derived by tuning the model to mimic historic flows representing the proportion of water entering each section of the water system. In the model, the formulas are currently based on a combination of whether or not a precipitation event has taken place at the sea, the number of crop acres being cultivated, Imperial Dam reservoir storage volume, and Colorado River flow volume upstream of the Imperial Dam. In reality, Colorado River flows are managed using a complex, dynamic legal framework known as "Law of the River" in order to meet the following: agricultural diversion orders, required deliveries to Mexico, storage requirements, flood control, and hydroelectric power generation contracts (Gleick et al., 2002). The volume of water flowing in the Colorado River determines water levels in the state variables representing the Palo Verde Diversion Dam, the Imperial Dam, the Laguna Dam, the Morelos Dam, and the Colorado River Delta. A portion of the water from the Colorado River is diverted through the All American Canal, a portion of which is diverted into the Coachella Canal which carries water to the Coachella Valley. Water that is not diverted into either the AAC or the Gila Gravity Main Canal exits the Imperial Dam, assuming the reservoir is above 13,250 acre-feet in the model, and flows downstream to the Laguna Dam. The reservoir storage of Imperial Dam alone is only about 1,000 acre-feet (Owen-Joyce and Raymond, 1996) but for modeling purposes the storage capacities of Senator Wash Dam, 2 miles upstream, (approximately 13,840 acre-feet) and the Imperial Dam are combined (Owen-Joyce and Raymond, 1996).

If the Imperial Dam is less than the parameterized flow through limit of 13,250 acre-feet in the model, then the assumption is that only 1,000 acre-feet (constant) of water is released until the reservoir fills to at least 13,250 acre-feet. Laguna Dam operates in a similar manner except that the reservoir storage capacity is only 1,000 acre-feet, based on information obtained from the U.S. Bureau of Reclamation (USBR), Lower Colorado Region (1996) and assuming dredging operations. The assumption is made that releases are 500 acre-feet or less unless storage capacity is met. Colorado River flows exiting the Laguna Dam reach Morelos Dam (no significant storage capacity) and are either diverted into the Alamo Canal, which flows into the Alamo River, the Mexicali Aqueduct which implicitly is diverted into other canals in Mexico, or flows downstream to the Colorado River delta.

The New River flow in Mexicali, MX is based on water drawn into the Mexicali aqueducts and canals (represented as one material transfer) from the Colorado River. New River flows in the Mexicali portion of the model implicitly include Mexicali Aquifer pumping runoff, but this water volume is adjusted in the form of reduced seepage loss from the aqueduct and canal transfer, and thereby the Mexicali Aquifer pumping is not explicitly represented in the model. However, simulated water flows from the IV enter the New River at a point above the state variable representing the New River volume at Mexicali. Downstream flow of the Colorado after the point of the Alamo Canal and Mexicali Aqueduct diversions is directed down the Colorado River to the river delta after which any remaining water would enter the Gulf of California.

Salton Sea Water Volume Sub-model

The Salton Sea water volume sub-model is comprised of the ‘Sea Vol’ state variable representing the volume of water in the sea (Fig. A.81.B in Appendix A), as well as respective elevation and surface area. Two material transfers represent the total water volume entering the sea from precipitation (‘Precipitation’) and river and agricultural runoff inflow (‘River Inflow and Ag Runoff’). Five material transfers represent the total water volume leaving the sea through the removal of brine for salt extraction (‘Sea Losing Brine’), evaporation from the exposed sea bottom (‘Exposed Sea Bottom Evaporating’), evaporation (‘Salton Sea Evaporation’), transpiration (‘Transpiration’), and north impoundment discharge water (‘Subtract for Impoundment’).

The ‘Sea Losing Brine’ material transfer represents the proposed enhanced evaporation ponds to remove salt from the sea. The ‘Subtract for Impoundment’ material transfer only operates if the impoundment scenarios are implemented. Upon implementation of impoundment scenarios, water transfers take place when the north impoundment (main sea) has reached a stabilized -220 fasl elevation at which point excess water is then shunted to the south impoundment. The model accounts for the volume of the Salton Sea as a non-divided sea and is represented using the following equation:

$$SS_{v(t+1)} = SS_{v(t)} + \Delta SS_v * \Delta t \quad (1)$$

$$\Delta SS_v = P + R_i + A_r - E - B_e - T_o - B_o \quad (2)$$

where:

$SS_{v(t)}$ = Salton Sea water volume in acre-feet at time t,

ΔSS_v = change in Salton Sea volume in acre-feet day^{-1}, P = precipitation falling in acre-feet day^{-1} on the sea surface, sea surface area (in acres) based on a USBR (1985) volume/elevation/surface area correlation,

R_i = inflow from rivers, canals, and creeks in acre-feet day^{-1},

A_r = agricultural runoff and groundwater seepage in acre-feet day^{-1},

E = evaporation from open water surfaces (Salton Sea) in acre-feet day^{-1},

B_e = evaporation from exposed sea bottom in acre-feet day^{-1},

T_o = transpiration in acre-feet day^{-1} from vegetation on exposed sea bottom and vegetation bordering the sea, and

B_o = volume of water in brine extracted from the Salton Sea in acre-feet day^{-1}.

The model also accounts for the division of the Salton Sea into two impoundments and is represented using the following equation:

$$SS_{v(t)} = SS_{vis(t)} + SS_{vin(t)} \tag{3}$$

$$SS_{vis(t+1)} = SS_{vis(t)} + \Delta SS_{vis} * \Delta t \tag{4}$$

$$\Delta SS_{vis} = P' + R_i + A_r' - E' - B_e' - T_o' - B_o' - SS_o \tag{5}$$

$$SS_{vin(t+1)} = SS_{vin(t)} + \Delta SS_{vin} * \Delta t \tag{6}$$

$$\Delta SS_{vin} = P'' + A_r'' - E'' - B_e'' - T_o'' - B_o'' + SS_o \tag{7}$$

where

$'$ = portion of respective variable's volume in acre-feet day^{-1} in the stabilized impoundment,

$''$ = portion of respective variable's volume in acre-feet day^{-1} in the non-stabilized impoundment,

$SS_{vis(t)}$ = stabilized sea impoundment volume in acre-feet at time t,

ΔSS_{vis} = change in stabilized sea impoundment volume in acre-feet day^{-1},

$SS_{vin(t)}$ = non-stabilized sea impoundment volume in acre-feet at time t,

ΔSS_{vin} = change in non-stabilized sea impoundment volume in acre-feet day^{-1}, and

SS_o = outflow volume in acre-feet day^{-1} from stabilized to non-stabilized impoundments of the sea.

Salton Sea Evapotranspiration Sub-model

The Salton Sea evapotranspiration sub-model determines the amount of surface water evaporation taking place at the sea based on the surface area and specific gravity of the sea. The state variables ‘Salton Sea TDS Mass Kg’ (TDS mass in kilograms) and ‘Sea Vol’ (acre-feet of water) and one constant ‘Fresh Water Density’ (1.234 x 10^6 kg/acre-foot) are connected via information transfers to the auxiliary variable ‘Spec Gravity’, which determines the specific gravity of the water in the sea. More specifically, the volume of the sea in acre-feet was multiplied by the fresh water density of 1.234 x 10^6 kg/acre-foot, the product added to the sea’s total mass of TDS, and then divided by the product of the sea’s volume multiplied by the fresh water density constant. The ‘Spec Gravity’ auxiliary variable connects to the ‘SG Evap Mult’ auxiliary variable via an information transfer and determines the evaporation rate of water given the specific gravity (Table B.93 in Appendix B). When Salton Sea water has a higher concentration of TDS the evaporation rate decreases as described in Tetra Tech, Inc. (2000).

The ‘SS Evaporation AcreFeet’ auxiliary variable determines the amount of sea water evaporation that takes place. Information transfers feed into the ‘SS Evaporation

AcreFeet' auxiliary variable from the following: the surface area constants which provide the surface area of the sea with and without impoundment scenarios, 'Salton Sea Not Divided SA Decision' and 'North Lake Impounded SA Decision', respectively, 'Impound Decision' and 'Year Impounded', respectively; the constants providing information on when and which impoundment scenario being implemented; the 'Freshwater Evap Rate' constant which provides the evaporation rate associated with freshwater; the 'Inches to Feet conversion' constant and 'Calculated Evaporation' and 'SG Evap Mult' auxiliary variables. In order to determine sea surface evaporation, an open water evaporation coefficient of 0.69 (Weghorst, 2004) is multiplied by historic and simulated reference Eto (see Chapter III) in the 'Calculated Evaporation' auxiliary variable.

Water loss (acre-feet day^{-1}) from the sea via evaporation (E) is calculated based on the surface area (SA, in acres) of water, assuming a freshwater evaporation rate (FER) determined using the methodology developed and previously mentioned in Chapter III of this document, about 5.78 feet/yr (Setmire, 2000), and an initial specific gravity (SG) of 1.04 for water in the sea (Mono Lake model parameter (Ford, 1999)), as:

$$E = SA * FER * SG \qquad (8)$$

Evapotranspiration (acre-feet day^{-1}) from the sea is calculated as 5% of evaporation in the 'Calculated Transpiration' auxiliary variable. Water may also be lost from the sea via brine extraction using a brine extraction constant variable 'Brine Extraction'. Water loss via evaporation and transpiration from Brawley and Imperial wetlands is calculated based on wetland surface area (acres), using the same approach for determining evapotranspiration for the sea. Weghorst (2002) assumed a loss rate of 4.38 acre-feet/acre-yr which could be interpolated as 0.012 acre-feet/day; however such an interpolation would dampen patterns of seasonality and rainfall event effects and therefore was not used in our model parameterization.

Salton Sea Precipitation Sub-model

The Salton Sea precipitation sub-model calculates the volume of water entering the sea by means of precipitation. Precipitation events are calculated based on using both the historic frequency distributions, for the years 1980 to 2004, for the total number of precipitation days, precipitation volume in inches, and duration of precipitation events in days (see Chapter III). Because the duration of precipitation events is decided after a precipitation event occurrence has been selected; the number of simulated precipitation events tends to be inflated. An adjustment was made using a Monte Carlo procedure to select only 75% of precipitation events from the overall simulated number of events.

The ‘Sea Area’ auxiliary variable calculates the surface area of the sea. The ‘Exposed Sea Bottom Area’ auxiliary variable calculates the exposed sea bottom acreage. Along with the ‘Precipitation Rate’ driving variable, these variables provide the data via information transfers that allow the ‘Sea Precipitation’ auxiliary variable to compute the total volume of precipitation at the Salton Sea.

Salton Sea Water Balance Sub-model

The Salton Sea water balance sub-model consolidates precipitation, run-off, groundwater, river flow, and agricultural drains in an inflow auxiliary variable (‘Total In’). Surface water evaporation, transpiration, exposed sea bed evaporation, brine extraction, and impoundment discharge are consolidated in an outflow auxiliary variable ('Total Out').

Salton Sea River Inflows Sub-model

River flow calculations include inflows to the sea from the Whitewater River (driving variable), the Alamo River (simulated), and the New River (simulated). The river inflows sub-model calculates the total daily river inflow to the sea by the variables: 'Whitewater R Inflow', 'Alamo R Inflow', and 'New R Inflow'. The simulated river flows are tuned to resemble historical river flows using data recorded from 1980 through 2004 at the United States Geological Survey (USGS) gage stations #10259540, #10254730, and #10255550, respectively. Other inflows entering the sea by means of surface run-off, groundwater, and miscellaneous agricultural drains are calculated by the auxiliary variable 'Other Miscellaneous' by summing the corresponding rate constant variables: 'Groundwater', 'Other Surface', and 'Agricultural Drains'.

Currently the model assumes that of the volume of water delivered to the Coachella Valley; about one third becomes agricultural runoff (seepage implicit) to the sea from the Coachella Valley (IID and CH2MHill, 2001), represented by the material transfer 'Ag Drains to SS' in the model. The variable 'Agricultural Drains' represents the volume of the agricultural runoff entering the sea. The *Layperson's Guide to the Salton Sea Draft EIS/EIR* (Bureau of Reclamation and Salton Sea Authority, 2000) lists agricultural drains, ground water, and other surface inflows as 8%, 4%, and 1%, respectively, of total inflows to the sea. Therefore, the model assumes that 12.5% of the volume attributed to agricultural runoff 'Agricultural Drains' is approximately equivalent to the volume attributed to other surface runoff ‘Other Surface’. In turn, groundwater is assumed to be approximately half the volume of ‘Agricultural Drains’. In the case of impoundment scenario 2 in which the sea is essentially divided in half, the ‘Other Miscellanous’ volume is halved with each respective volume allotted for the north and south impoundments.

Salton Sea Exposed Sea Bottom Sub-model

The exposed sea bottom sub-model is designed to calculate the area in acres of exposed lakebed, its evaporation rate (assumed 5 percent increase) and volume of evaporation. The auxiliary variable ‘Exposed Sea Bottom Evap Rate’ calculates the rate of evaporation from the sea exposed seabed based on information transfers from the auxiliary variables: ‘Calculated Evaporation’ representing overall evaporation at the sea, ‘SG Evap Mult’ representing the relationship between specific gravity and evaporation, and the constant ‘Exposed Sea Bottom Evap Mult’ representing the amount of increased evaporation for seabed mud (5 percent). The ‘Exposed Sea Bottom Area Evaporation’ auxiliary variable determines the amount of evaporation water loss based on the ‘Exposed Sea Bottom Evap Rate’ auxiliary variable and the ‘Exposed Sea Bottom Area’ auxiliary variable, which calculates the number of acres of exposed seabed. The ‘Exposed Sea Bottom Area’ auxiliary variable is determined by the number of acres of exposed seabed as determined by the present number of acres of sea area (an auxiliary variable selecting the surface area of the whole sea or divided sea scenario) subtracted from the previous number of acres of exposed seabed (‘Previous Salton Sea SA in Acres’ state variable).

Water Quality Sub-models

The Salton Sea water quality sub-model represents changes in water quality represented as TDS in the sea resulting from river flow and brine extraction, as well as phosphorous entering the sea. Phosphorous (P) was chosen for analysis over other nutrients due to the fact that is by far the potential limiting nutrient in the sea, and responsible for stimulating primary productivity in the sea, a eutrophic to hypereutrophic water body (Setmire, 2000). Setmire (2000) states that, "any efforts to reduce eutrophication in the Salton Sea needs to focus on P removal…" The concept is that by reducing P one may reduce algal blooms and potential anoxic conditions produced thereafter that can lead to fish and bird die-offs.

TDS and P in river inflows include contributions from the Whitewater River, the Alamo River, and the New River. The sea water quality sub-model is tuned to mimic historical TDS and P seasonal fluctuations however TDS and P initial parameters are currently based off of annual averages. Run-off TDS also enters the sea from the Coachella Valley via a material transfer. In total, TDS is tracked at 17 locations, not including the Salton Sea. Three water quality sub-models, e.g. Evaporation, Mass Fluxes, and TDS, represent each location responsible for tracking water quality and ultimately determining water quality in the sea. Phosphorous mass balance is accounted for in the same manner as TDS in the model.

<u>Salton Sea TDS and P Mass Fluxes Sub-models</u>

Salinity (TDS) of the sea is determined by the total inflow mass of TDS minus the total outflow mass. When two different water volumes and associated salinities converge, the weighted average of the mass of TDS was calculated yielding a new salinity for the new flow volume. Although the units of measure throughout the model are in acre-feet of flow and kg of TDS, a conversion is made using one acre-foot of water equals 1,233,481.84 liters and 1 kg of TDS equals 1,000,000 mg. The conversion provides a salinity measurement in mg/L which is equivalent to parts per million (ppm).

Salt in the form of TDS enters the sea via river inflows and agricultural drains and exits the sea through brine extraction or water transfer in the impoundment scenarios. TDS in river inflows includes contributions from the Whitewater River, the Alamo River, and the New River. The sub-models are tuned to mimic historical TDS however TDS data are currently based off of annual averages (Setmire, 2000). Agricultural run-off TDS enters the sea from the Coachella Valley via the "Ag Drain to SS" material transfer.

The Salton Sea TDS mass fluxes sub-model calculates the different river salinities at the sea inlets based on the auxiliary variable 'Total Mass Input to Sea by Inflows' (kg/day) which relies on information transfers from the 'Total Mass Input to Alamo R by Inflows Kg', 'White Water R Mass Input Kg', 'Weighted Average New River NRWP TDS Kg' and the 'SS Other Misc Mass input Kg' auxiliary variables. The 'White Water R Mass Input Kg' auxiliary variable is calculated based on data from the auxiliary variables 'Mg per Kg' and 'Liters per Acre Foot', the material transfer 'White Water River', and the state variable 'White Water River TDS Mass Kg'. The 'Total Mass Input to Alamo R by Inflows Kg' auxiliary variable is determined based on data from the auxiliary variables 'Mg per Kg' and 'Liters per Acre Foot', the material transfer

'Alamo 3', and the constant 'Alamo R Total TDS Mass Kg'. The 'Weighted Average New River NRWP TDS Kg' auxiliary variable is calculated based on data from the auxiliary variables 'Mg per Kg' and 'Liters per Acre Foot', the state variable 'New R 2' Inflow, and the constant 'New River NRWP TDS Mass Kg'.

The state variable 'Salton Sea TDS Mass Kg' receives dissolved solids via the 'Inflow Mass TDS Kg' material transfer, based on the auxiliary variable 'Total Mass Input to SS', and loses dissolved solids via the 'N Imp Brine Extraction' material transfer, which represents mechanical extraction through the solar evaporation ponds (Brine Extraction driving variable). The extraction of the brine is calculated by the 'Salt Extraction' auxiliary variable that utilizes information from the volume and salinity of the sea water (Salton Sea state variable), the mass of dissolved solids in the sea (sea TDS mass), the number of liters in an acre foot of water ('SS Liters per Acre Foot' constant), the number of mg in a kg ('SS Mg per Kg' constant). In much the same way, the 'Overflow to South Impounded Lake TDS KgDay' material transfer removes TDS when the impoundment scenarios are implemented.

Water quality is calculated for the individual canals, rivers, and wetlands using the same method mentioned above for the sea. For example, tuning the model to mimic the TDS of agricultural drainage was accomplished by multiplying the TDS (g/L) of the AAC, varying between 0.75 and 0.78 (a stochastic variable), by a constant of 3.6 and 3.55 for tiled and non-tiled agricultural acres, respectively. In order to track P entering the sea, a replicate of the TDS sub-models was created and parameterized. Table B.94

in Appendix B contains the TDS and P parameters used in different locations within the model.

Mass is calculated based on the concentrations of Total Dissolved Solids (TDS) and Phosphorous (P) for given water volumes using the following equations:

$$SS_{TDS(t+1)} = SS_{TDS(t)} + \Delta SS_{TDS} * \Delta t \quad (9)$$

$$\Delta SS_{TDS} = R_{im} + A_{rm} - B_{om} \quad (10)$$

$$SS_{visTDS(t+1)} = SS_{visTDS(t)} + \Delta SS_{visTDS} * \Delta t \quad (11)$$

$$\Delta SS_{visTDS} = R_{im} + A_{rm} - B_{om}{'} - SS_{om} \quad (12)$$

$$SS_{vinTDS(t+1)} = SS_{vinTDS(t)} + \Delta SS_{vinTDS} * \Delta t \quad (13)$$

$$\Delta SS_{vinTDS} = R_{im} + A_{rm} + B_{om}{''} + SS_{om} \quad (14)$$

$$SSR_{Pi\ (t+1)} = SSR_{Pi(t)} + \Delta SSR_{Pi} * \Delta t \quad (15)$$

$$\Delta SSR_{Pi} = R_{Pim} - W_{om} \quad (16)$$

where:

$'$ = portion of respective variable's TDS mass in kilograms day^{-1} in the stabilized impoundment,

$''$ = portion of respective variable's TDS mass in kilograms day^{-1} in the non-stabilized impoundment,

$SS_{TDS(t)}$ = Salton Sea TDS mass in kilograms at time *t*,

ΔSS_{TDS} = change in Salton Sea TDS mass in kilograms day^{-1},

$SS_{visTDS(t)}$ = stabilized sea impoundment TDS mass in kilograms at time *t*,

ΔSS_{visTDS} = change in sea stabilized impoundment TDS mass in kilograms day^{-1},

$SS_{vinTDS(t)}$ = non-stabilized sea impoundment TDS mass in kilograms at time *t*,

ΔSS_{vinTDS} = change in sea non-stabilized impoundment TDS mass in kilograms day^{-1},

$SSR_{Pi(t)}$ = Salton Sea inflow P mass in kilograms at time *t*,

ΔSSR_{Pi}= change in sea inflow P mass in kilograms day^{-1},

R_{im} = river, canal, and creek inflow TDS mass in kilograms day^{-1},

R_{Pim} = inflow P mass in kilograms day^{-1},

A_{rm} = agricultural runoff and groundwater seepage TDS mass in kilograms day^{-1}.

B_{om} = TDS mass outflow in kilograms day^{-1} via brine extraction,

SS_{om} = transferred mass in kilograms day^{-1} of TDS from stabilized to non-stabilized impoundments of the sea, and

W_{om} = Wetland phosphorous outflow mass in kilograms day^{-1}.

Agricultural Sector

Agriculture in the IV is divided into two classes, tiled and non-tiled fields. About 390,000 acre-feet of water enters the drainage system as tailwater and 394,200 acre-feet as tilewater (IID and CH2MHill, 2001). For modeling purposes, it was assumed that the percentage of tiled (50%) versus non-tiled (50%) acres in the IV is equal. There is an additional 18% water requirement (a constant) for flushing salt (leaching) tile acres based on average water requirements per tile acre cited as 5.6 acre-feet per acre versus water per non-tile acre cited as 4.6 acre-feet per acre (Rea & Parker Research, 2002).

The IV crop acreages and percentages growing per month simulated in the model consist of ten distinct crop types or aggregations: (1) Sorghum, (2) Maize, (3) Wheat, (4) Cotton, (5) Alfalfa, (6) Vegetable, (7) Fruit, (8) Miscellaneous Cereal Crops, (9) Miscellaneous Forage Crops, and (10) Other (Figs. A.82-A.85 in Appendix A). Each land use category has an equivalent water demand based on the scientific literature (Fig. A.86 in Appendix A). The user can also change the total number of acres farmed using the user interface Total Ag. The IV has on average 460,000 and the Coachella Valley has 60,000 acres (Colorado River Board of California, 1992). Annual agricultural water requirements for the IV are defined by the following equation:

$$A_{wr} = (\sum_{i}^{10} WD_i * A_{cai}) \qquad (17)$$

where:

A_{wr} = Agricultural annual water volume requirement in acre-feet for the IV,

A_{cai} = Agricultural crop acreage planted for the *i*th crop type, and

WD_i = water demand in acre-feet per acre for the *i*th crop type.

In this way the IV annual water demand is met and apportioned on a daily basis for each crop type over the growing season. The average annual crop consumptive volume from irrigation was estimated as 1,705,500 acre-feet while the average annual deliveries to farms in the IID was 2,489,700 acre-feet, a crop consumptive use of 68.5 percent (IID and CH2MHill, 2001). The present study assumes a constant crop consumptive use of 60 percent of irrigation volume from the AAC, after seepage losses.

Fallowing agricultural land will lead to economic consequences in the IV and surrounding area. The model addresses potential agricultural economic consequences, largely dependent upon which agricultural sector is affected (Fig. A.87 in Appendix A), by accounting for the number of agricultural jobs within a given agricultural employment sector within the IV (Figs. A.88 & A.89 in Appendix A). The impact that fallowing farmland may have in the region is a function of the increase or decrease in agricultural farmland multiplied by the number of agricultural jobs acre^{-1} for a given agricultural sector.

Using agricultural employment data for the IV, the ten crop types were sorted into seven categories of agricultural employment and the acreages divided by the number of jobs per employment category to obtain the number of jobs acre^{-1} of cropland per category, a linear interpolation. The agricultural employment categories were the following: (a) Food Grains & Misc. Crops consisting of Maize, Misc. Cereal Crops, Sorghum, and Wheat acreages, (b) Hay, Pasture, & Grass Seed consisting of Misc. Forage Crops and Alfalfa acreages, (c) Total Livestock & Products consisting of Alfalfa, Maize, Misc. Forage Crops, Misc. Cereal Crops, Other, Sorghum, and Wheat acreages, (d) Cotton and respective acreage, (e) Fruit and respective acreage, (f) Vegetable and respective acreage, and (g) Other and respective acreage.

Human Population Growth

The human population growth sub-model quantifies human population changes and determines the water demands for San Diego and Mexicali. Changes in total jobs for each of the agricultural employment categories combined with a reduction in crop acreages is directly linked to the local economy which in turn affects population growth in the region. A decrease in agricultural employment is assumed to lead to a decrease in population via the negative effects on the local economy. Such a decrease in population is dependent upon any changes in the Industrial sector, in light of the constraint on water consumption. Perhaps growth of industry in the IV could compensate for the agricultural employment losses, but this remains an uncertainty. Currently, the assumption is that there will be a decrease in the IV population as a negative effect of agricultural fallowing on the agricultural employment sector. The IV projected annual population growth rate, based on Pick et al. (2003) in Table B. 95 in Appendix B, is modified based on feedback from the agricultural employment sector in the form of a reduction or increase in the percent of current agricultural jobs compared to initial agricultural jobs. The percentage increase or decrease of agricultural jobs is multiplied by the projected population growth for the next year, leading to a respective increase or decrease in the annual population growth which is incorporated into the model on a daily time-step.

The changes in water demand due to population change in the IV are implemented in the model by either reducing or increasing water draws from the All American Canal. Two auxiliary variables calculate the consumptive water use based on population, one for Mexicali and the other for the IV, assuming that one acre-foot of water is enough to sustain two households of four people each for one year (Conaughton, 2001). Therefore, by estimating the population change in Imperial County and Mexicali for a given time period, one can also project the changes in water demand for these locations. The change in population related consumptive water demand has a direct impact on water available for agricultural uses and hence flows in the form of agricultural runoff to the Salton Sea. The impact that agricultural fallowing and agricultural employment has on population change in the IV is directly related to water consumption and can be expressed using the following equation:

$$IV_{wd(t)} = P_t * W_{pc} \tag{18}$$

$$P_{t+1} = P_t + (PP_{Ga})\Delta t \tag{19}$$

$$PP_{Ga} = P_{Ga} * \left(\sum_{i}^{7} A_{eci} / \sum_{i}^{7} A_{ei}\right) \tag{20}$$

where:

IV_{wd} = consumptive water demand volume in acre-feet year^{-1} in the IV,

A_{eci} = current jobs acre^{-1} for the ith agricultural employment category in the IV,

A_{ei} = initial jobs acre^{-1} for the ith agricultural employment category in the IV,

P_t = current population size in the IV,

P_{t+1} = new population size in persons year^{-1} for the IV,

W_{pc} = IV consumptive water use capita^{-1} year^{-1},

PP_{Ga} = employment adjusted population growth trend (persons year^{-1}) in the IV, and

P_{Ga} = population growth trend (persons year^{-1}) in the IV (Pick et al. 2003).

Population change in Mexicali is independent of agricultural changes in the IV. Any effect on population growth in Mexicali via agricultural employment in the IV is assumed to be negligible due to employment growth in Mexicali's industrial sector. Further, fallowing does not take place in the Mexicali Valley and therefore is not an option in the model. The projected annual population growth rate for Mexicali, based on Pick et al. (2003) Table B.95 in Appendix B is utilized. Mexicali water consumption attributed to population change can be expressed using the following equation:

$$M_{wd(t)} = MP_t * WM_{pc} \tag{21}$$

$$MP_{t+1} = MP_t + (MP_{Ga})\Delta t \tag{22}$$

where:

M_{wd} = consumptive water demand volume in acre-feet year^{-1} in Mexicali,

MP_{t+1} = new population size in persons year^{-1} in Mexicali,

MP_t = Mexicali current population size in number of people,

MP_{Ga} = population growth trend (persons year^{-1}) in Mexicali (Pick et al., 2003), and

WM_{pc} = Mexicali consumptive water use capita^{-1} year^{-1}.

The changes in water demand due to population change in Mexicali are implemented in the model by either reducing or increasing water draws from the New River. The change in population related consumptive water demand has a direct impact on water available in the form of urban and agricultural runoff to the sea by means of the New River.

Policy Specific Sub-models

<u>Wetlands (Policy 1)</u>

The wetlands reduce the New River historical flow by the estimated water volume lost through wetland surface area evaporation. The wetlands also reduce phosphorous and increase dissolved oxygen by specified amounts based on preliminary results from the New River Wetlands Project. The wetland pilot projects have resulted in a reduction in total solids in excess of 90 percent and an increase in dissolved oxygen, evidence the wetlands are doing what was expected. The increased number of artificial wetlands along the New River reduces dissolved solids, but in trade, increases the volume of water lost through evaporation. Using the Brawley New River Wetland as an example, evaporation is captured by the auxiliary variable ‘Brawley Wetland SA’, as the surface area of the wetland increases so does the evaporation volume, similar to Salton

Sea evaporation. The ‘Wetland Water Volume Brawley’ auxiliary variable determines the amount of water that enters the wetland ‘Stage 1’ state variable, via the ‘Brawley Wetland flow’ and ‘Water entering Wetland’ material transfers. The ‘Wet Evap’ material transfers represent the amount of water lost to evaporation. The remaining water flows back into the New River via the ‘Water Exiting Wetland’ and material transfer.

Two main components of the wetland sub-models include the following: two differentiated wetland constructs resembling the Brawley and Imperial wetlands, where the Brawley wetland is “cleansing” New River water, and the Imperial wetland is “cleansing” agricultural runoff into the New River. The New River wetlands pilot project began operating in 2001. Based on Imperial wetland data (New River Wetlands Project, 2000), phosphorous was reduced from 1.95 mg/L from inlet to 0.57 mg/L at outlet signifying a 71 percent reduction in phosphorous. Based on Brawley wetland data, phosphorous was reduced from 1.59 mg/L from inlet to 0.73 mg/L at outlet meaning a 54 percent reduction. In order to subtract 54 percent of P over 18 time-steps under the Imperial wetland design or 71 percent of P over 9 time-steps under the Brawley wetland design (New River Wetlands Project, 2000), using the constant daily P removal rates of 0.083 and 0.066, respectively.

Using the model user interface, the number of wetlands can be increased, and hence the number of wetland acres increased, to “process” even more water using the Brawley wetland construct, the Imperial Wetland construct, or both wetland constructs simultaneously. The model assumes that future wetland designs stay the same as the current designs where the Imperial wetland holds 22.7 acre-feet of water and the Brawley wetland holds 6 acre-feet of water (New River Wetlands Project, 2000). The model assumes that an additional 8 (10 total) wetlands are constructed, 5 of each design, for simulated future scenarios.

Salton Sea Impoundments (Policy2)

The model incorporates optional impoundment scenario designs for the sea, which may be included in the simulations, or not included by default, using the model user interface, i.e., "Impound" and "Scenario" variables. The water volume storage capacity of the impoundments varies depending upon the scenario selected via the user interface level of the model. The impoundments are designed to accept overflow from the sea when the water volume storage capacity is surpassed. The north impoundment (main sea) is considered stabilized at an elevation of -220 fasl with a corresponding storage capacity of 4,144,717 acre-feet and 6,338,009 for impoundment scenarios 2 and 3, respectively. For each impoundment there are 7 sub-models associated with water volume, water flow, and water quality (3 sub-models for each water quality constituent of interest, e.g. TDS and P, at each location where water quality is tracked).

Agriculture & Fallowing (Policy3)

The Imperial Irrigation District (IID) has a plan to meet San Diego water needs by redirecting water originally slated for agriculture in the Imperial Valley (IV). The IID data have been incorporated into the model so that water slated for San Diego is subtracted from IV water available for agriculture, which results in a reduction in the respective amount of crop acres to meet the water demand volume. More specifically, two constants, representing the number of acres fallowed and the water volume, in acre-feet, per acre fallowed determine how much water is actually saved by setting aside a specified amount of farmland. A material transfer routes the conserved water to a state variable representing San Diego water use. Currently, the assumption is made that 90% of fallowing occurs on non-tiled agricultural land as a result of poorer water conservation versus the tiled agricultural land. The model user interface allows for the fallowing of selected acreages for each of the ten crop types. Currently, fallowing only occurs on Miscellaneous Forage Crops (80%) and Other (20%) (C.Z. Villalon, pers. Comm., 2002).

These two crop categories were chosen for fallowing due to the minimum economic impact in the IV versus the effect of fallowing other crops, as estimated by a couple of other studies. For instance, the number of acres that need to be fallowed is reduced from 53,286 to 37,500; harm to the IV's economy falls from $98 to $25 million; and job losses reduce from 1,400 to 521 (Rea and Parker Research, 2002). The user specifies the land use category or categories to be fallowed, and the amount of water no longer needed, as a result of fallowing the respective number of acres, is no longer drawn from the Colorado River via the All American Canal. Instead, two-thirds of the water volume conserved from fallowing is exported to San Diego, upstream. The remaining one-third of the water volume conserved from fallowing is still drawn from the Colorado River via AAC, after which it is shunted to the Salton Sea via the Alamo River as mitigation water.

Based on Cohen and Hyun (2006), "mitigation water is raw Colorado River water, with much lower salinity (currently about 0.73 g/L) than the agricultural drainage it replaces (about 2.5 g/L)." The mitigation water is sent through the AAC and New River to the Salton Sea the third month of each year that crop acreage fallowing occurs. Agricultural fallowing in the IV for San Diego consumptive uses and sea mitigation water is expressed by the following equation:

$$W_f = X_f + Y_f \tag{23}$$

$$X_f = (0.8 * W_f / WD_{MFC}) \tag{24}$$

$$Y_f = (0.2 * W_f / WD_{Other}) \tag{25}$$

where:

W_f = Volume of water in acre-feet redirected from the IV to San Diego and the sea via agricultural fallowing of crop acreages,

WD_{MFC} = water volume demand in acre-feet acre^{-1} planted year^{-1}for the agricultural crop type Miscellaneous Forage Crops,

WD_{Other} = water demand in acre-feet acre^{-1} planted year^{-1} for the agricultural crop type Other.

Power Plants (Policy 4)

The power plants are assumed to begin full operation in 2005 (day 9,133) in the model. A material transfer accounts for the water being transferred to the power plants, where a specified amount via a constant is lost, from the state variable representing water at the power plants, through evaporation and onsite consumptive use via a material transfer and therefore lost from the New River. The residual water not used by the power plants (assumed to be a constant 10 percent) flows back to the New River via a material transfer. It is important to note that only a small percentage of the entire New River flow is diverted for the power plants.

The Mexicali power plants draw water from the Mexicali portion of the New River. Under normal conditions, the respective mass of TDS and P of the water inflows to the power plants would be conserved in the outflows, although due to the evaporative water losses a higher concentration of effluent would be produced. There have been discrepancies (e.g. Border Power Plant Working Group (Plaintiff) versus Department of Energy and Bureau of Land Management (Defendants), 2003) as to what method and how effective power plants are or will be at reducing the TDS of the effluent, if at all. A conservative assumption of the power plants or waste water treatment plants implementing a mitigation TDS and P removal method (e.g. reverse osmosis) was assumed.

The power plant operated by SEMPRA evaporates an estimated 10.61 acre-feet day^{-1} while the Bechtel Intergen power plant evaporates an estimated 17.68 acre-feet day^{-1} (Kamp, 2001). The model user interface allows one to change the amount of water being used by a given power plant. For instance, if one would like to investigate the effects of additional power plants in the future, one simply needs to double or triple the daily water volume requirements.

$$PP_o = PP_i - PP_e \qquad (26)$$

where:

PP_o = Power plant outflow acre-feet day^{-1} returned to the New River,

PP_i = Power plant inflow acre-feet day^{-1} from Mexicali recycled wastewater and New River water, and

PP_e = Bechtel Intergen and SEMPRA power plant water use evaporation day^{-1}.

Lining of the All American Canal (Policy 5)

The model incorporates the proposed lining of the All American Canal by either allowing or prohibiting the flow of water to the Mexicali Aquifer as determined by a constant variable. Water is able to flow to the state variable representing the Mexicali Aquifer through a material transfer representing seepage, if the canal is not lined as the following equation translates:

$$C_U = C_F - (C_F * Q_S) \qquad (27)$$

where:

C_U= canal flow when not lined with concrete,

C_F = canal flow (acre-feet day^{-1}), and

Q_S = proportion of canal seepage to Mexicali Aquifer.

Under the scenario that the Canal Lining constant does not equal 0, hence the All American Canal has been lined with concrete and water does not flow into the Mexicali Aquifer, but instead transferred to a state variable representing the water volume available for IV agricultural use. The historical flow through the All American Canal, should it be lined with concrete, will increase by the amount of seepage that was estimated to occur, e.g. included in the model assumption of 13 percent, as an unlined canal. The 13 percent represents other water conservation measures that could save an additional 368,000 acre-feet mentioned in a study by the Colorado River Board of California (1992) but left implicit within the model.

The lining of the All American Canal and the Waste Water Treatment Facilities in Mexico are only operational if selected in the user interface. The year in which lining the AAC takes place in the future is optional, but the model currently assumes implementation on day one of 2009. The water losses from the AAC at present are an estimated 13% of AAC water flow volume. Once the AAC lining option and other miscellaneous conservation measures are implemented in the model, 13% of AAC water flow volume is no longer lost in the form of seepage, currently directed to the Mexicali Aquifer. The amount of water being lost to the aquifer is accumulated in the 'Mexicali Aquifer' state variable for the sake of comparison between AAC lined versus non-lined scenarios. Although pumping of the Mexicali Aquifer does take place for agricultural uses in the Mexicali Valley, it is not explicitly represented in the model.

Waste Water Treatment Facilities (Policy 6)

Mexicali wastewater treatment plants begin operating on day 9,133 of all the simulations for all policies examined. The assumption is made that only 10% of the increased water demand, due to population increases in Mexicali, is diverted from the New River and used for consumptive uses after water treatment. Since the treatment plant wastewater is discharged out of the Salton Sea watershed, the respective TDS load is removed from the New River in the model, an assumption based on the Salton Sea Ecosystem Restoration Program (2006). The model could be used to simulate variations in the number of wastewater treatment plants and associated water volumes receiving treatment; however, this feature was not utilized in the current set of policy simulations but could be an option for future research.

Brine Extraction (Policy 7)

The current pilot project, which began in 2001, removes only about 11 acre-feet year^{-1}. Therefore, using linear interpolation the model currently removes only 0.03 acre-feet of brine from the sea day^{-1}. A material transfer represents the removal of brine from the sea to the proposed desalinization solar ponds. The extraction of the brine is calculated by an auxiliary variable that utilizes information from the volume and salinity of the sea water to calculate the mass of dissolved solids in the sea to be removed with the respective water volume. The elevation of the sea should be reduced by the amount of brine (water volume) extracted. Similarly, the specific gravity is modified as a result of the TDS and corresponding water volumes being removed from the sea in the form of brine.

Model Evaluation

The model was evaluated based on its ability to simulate: (1) historic trends in Salton Sea inflows (except in the case of the Whitewater River, a driving variable), sea volume, sea TDS mass, and P mass entering the sea via inflows. Analysis of Variance (ANOVA) and the Bonferroni Multiple Comparison Post Hoc Test were used to quantify uncertainty of the projected state of the future system in terms of evaluating scenarios and sensitivity analyses of specific variables.

To verify that simulated water flows adequately represented historic flows, a series of 15-year simulations was run for calibration purposes, driving the model with the water flows recorded for the Colorado River, the Gila River, and the Whitewater River, at USGS gage stations #09429100, #09520500, and #10259540, respectively, from 1980 to 1994. The rate constants that control water flows downstream from these entry points were adjusted until simulated flows mimicked historic flows in the New River and Alamo River at USGS gage stations #10255550 and #10254730, respectively, just before entering the Salton Sea, and in the New River as it crosses the Mexico/U.S. border at USGS gage station #10254970. The flows of the All American Canal were also assessed using historic annual average total flow volume compared to simulated volumes.

A time series of direct measurements of water volume of the Salton Sea was not available. However, a time series of observations of the elevation, in feet above sea level (fasl) of the surface of the sea was available (USBR, 1985). Simulated water volume (WV) in acre-feet was converted to elevation (E) in fasl by using both: (1) elevation, surface area, and volume relationship data obtained from the USBR, and (2) a formula estimated by the USBR (1985),

$$E = -275 + (6.25 * (WV / 1000000)) \tag{28}$$

where:

E = elevation of the Salton Sea, and

WV = water volume of the Salton Sea.

However, the USBR correlation equation that converts volume to elevation for the Salton Sea produced slightly different results from the USGS measured data. By modifying the USBR volume to elevation equation to the following:

$$E = -275 + (6.27 * (WV / 999000)), \tag{29}$$

Using the above modification of the original USBR volume to elevation equation, the difference between the two fore-mentioned computational methods' results were minimized (Fig. 3). These conversions allowed for the comparison of simulated sea elevations with the USGS elevation data from 1980 to 2004.

The ability of the model to simulate the fluctuations in water flows and the water volume (elevation) of the sea was also assessed in a model validation exercise for the 10 years from 1995 to 2004. Similar to the calibration exercise, the model was driven using the historic water flow data and precipitation and evapotranspiration (Eto) data obtained from the aforementioned USGS gage stations and CIMIS weather stations, respectively. Figs. A.90 through A.93 (in Appendix A) illustrate the simulation of daily historic flows and total accumulated annual flows measured at USGS gage stations for the Alamo River and New River. A similar observation of historic versus either deterministic or stochastic simulated future flows of the driving variables for the Colorado River, Whitewater River, Gila River, precipitation, and Eto can be found in Figs. A.94 through A.103 in Appendix A. Figs. A.104 and A.105 in Appendix A illustrate the simulation of daily historic elevation and total accumulated annual inflows measured for the Salton Sea.

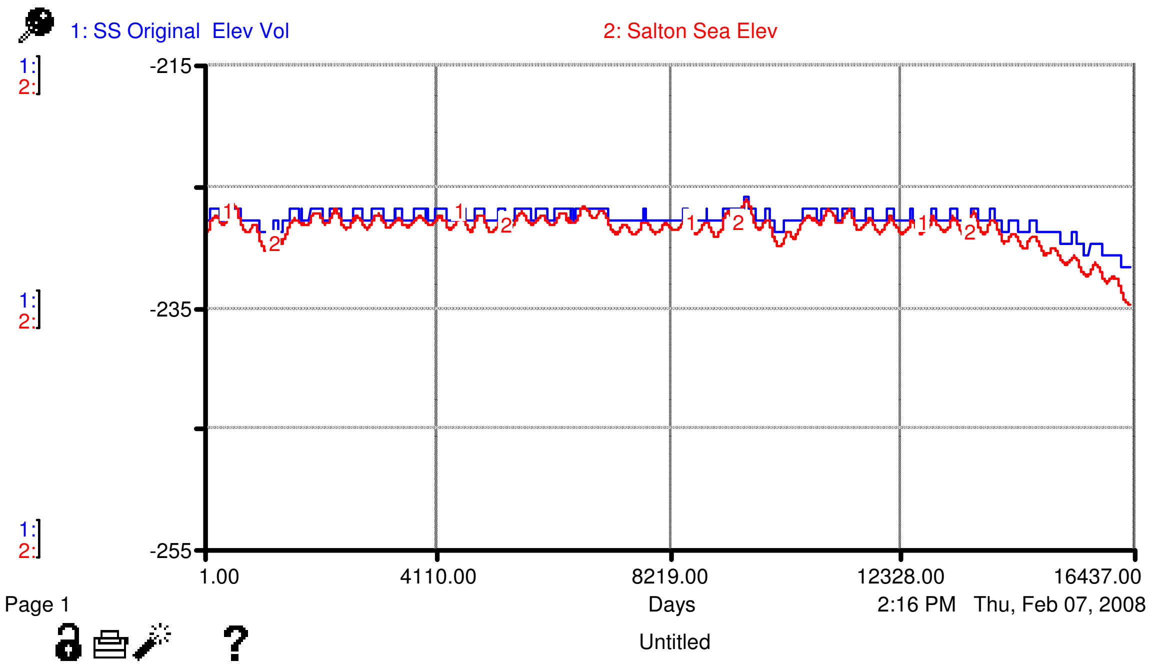

Fig. 3 - Simulated Salton Sea elevation based on volume and elevation correlation datasets from the USGS (1) versus a volume and elevation correlation equation (from the United States Bureau of Reclamation (USBR) (2).

Next, a comparison was made between the observed and simulated data as a means to assess the performance of the simulation model. Similar to Tong and Chen (2002), the error rate associated with model performance concerning sea elevation and sea salinity was calculated by subtracting the observed (historic) data from the simulated results and then dividing by the simulated results. In the validation exercise, the model simulated historic sea elevations to within 1 foot at its most disparate point, -228 fasl (simulated) & -229 fasl (historic), and maintained patterns of seasonality (Figs. 4 & 5). Based on the observed versus simulated sea elevation data, the model has an error rate of less than one percent, similar to the results of the study by IID and CH2MHILL (2001), meaning that the model has a reasonable ability to simulate the hydrology of the Salton.

Also, the graphs show that river flows and flow patterns are similar when comparing the simulated versus historic flows and can be considered acceptable as well.

With regard to Salton Sea salinity, the fore-mentioned error rate calculation method was utilized. However, water quality parameters were based on annual average data. Even though these data can be considered cruder in terms of temporal resolution when compared to river flow daily data, the results of simulating sea TDS were similar to the observed. More specifically, in the sea salinity validation exercise the most disparate underestimation of 2,999 ppm (44,788 ppm simulated versus 47,787 ppm observed) compared to the most disparate overestimation of 2,541 ppm (42,963 ppm simulated versus 40,422 ppm observed in Fig. 6).

Based on the observed versus simulated sea TDS data, the model has an error rate of about 7 percent at its most disparate point, and can be regarded as reasonable given that subsequent years' error rates are much less and the sea's general salinity trend does not change. The model verification results for salinity in a study by IID and CH2MHILL (2001) yielded about a 6 percent error rate at the most disparate point (1980 to 2000) and similar to results of the Salton Sea Ecosystem Restoration Program (2006).

As stated by IID and CH2MHILL (2001), if there was a problem with mass balance in either water volume or TDS mass accounting, then the model would not be able to replicate historic salinity and elevation values. IID and CH2MHILL (2001) mention that in their model, as in the present model, some differences in elevation and TDS between historic and simulated historic are likely caused by errors introduced in the

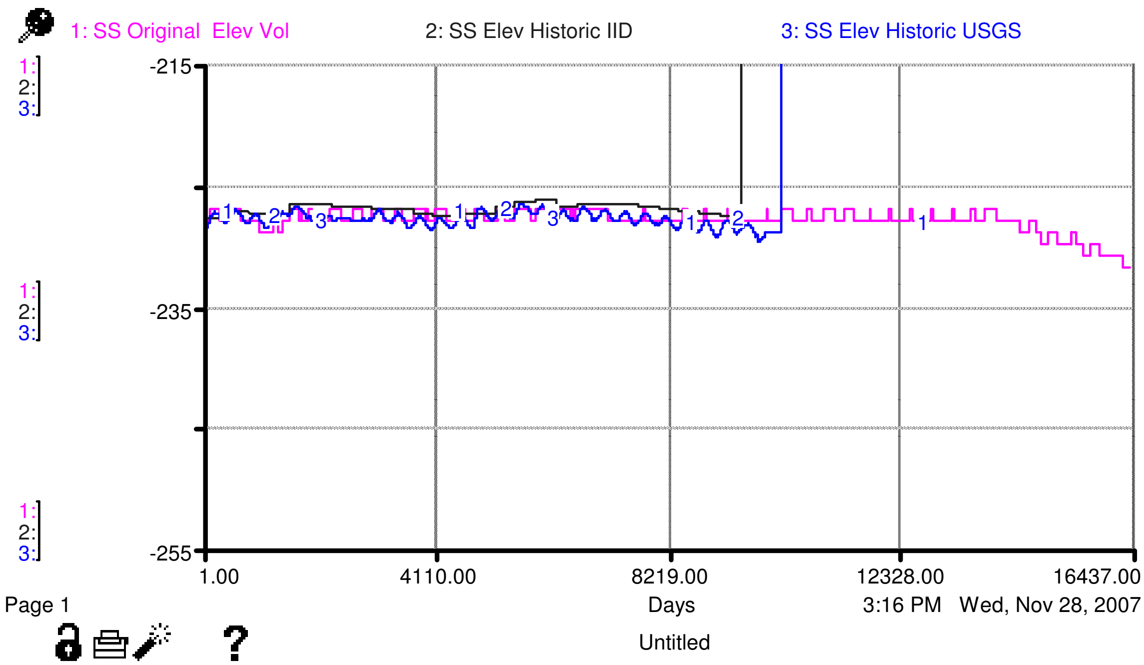

Fig. 4 - Historic elevation in feet above sea level (fasl) – Imperial Irrigation District (IID) annual data (2) and USGS daily data (3) versus simulated elevation (1) of the Salton Sea.

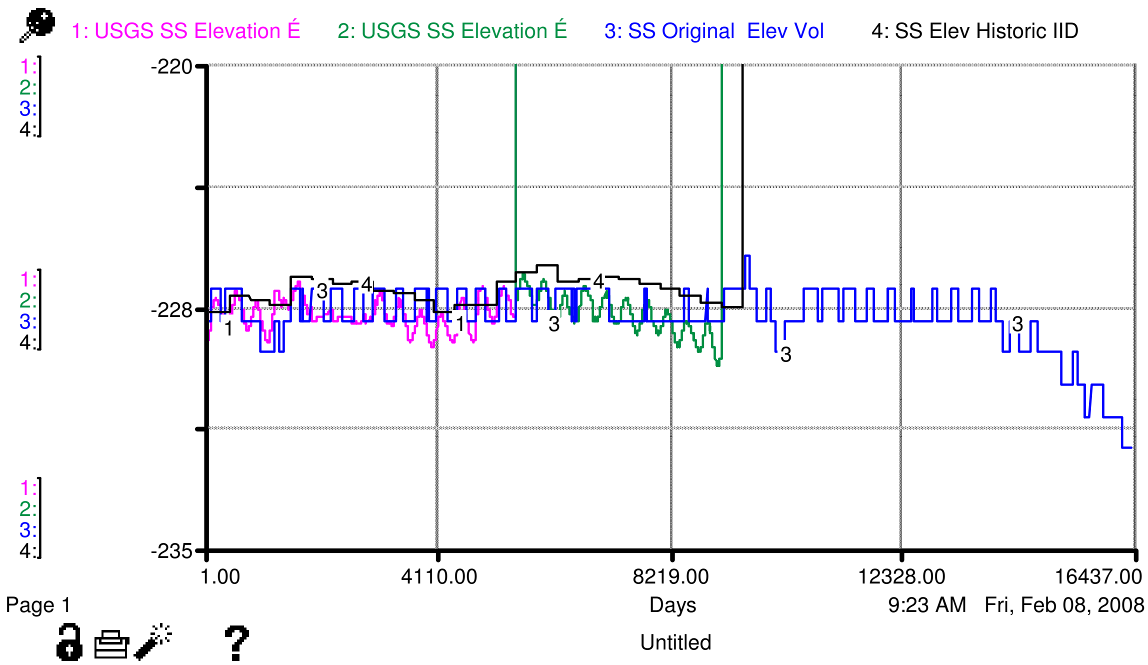

Fig. 5 - Salton Sea elevation in feet above sea level (fasl) – calibration using historic USGS daily data over a 15 year period (1980-1994) (1) validation using historic USGS daily data over a 10 year period (1995-2004) (2), simulated elevation of the Salton Sea (3), and historic Imperial Irrigation District (IID) annual data (1980-2005).

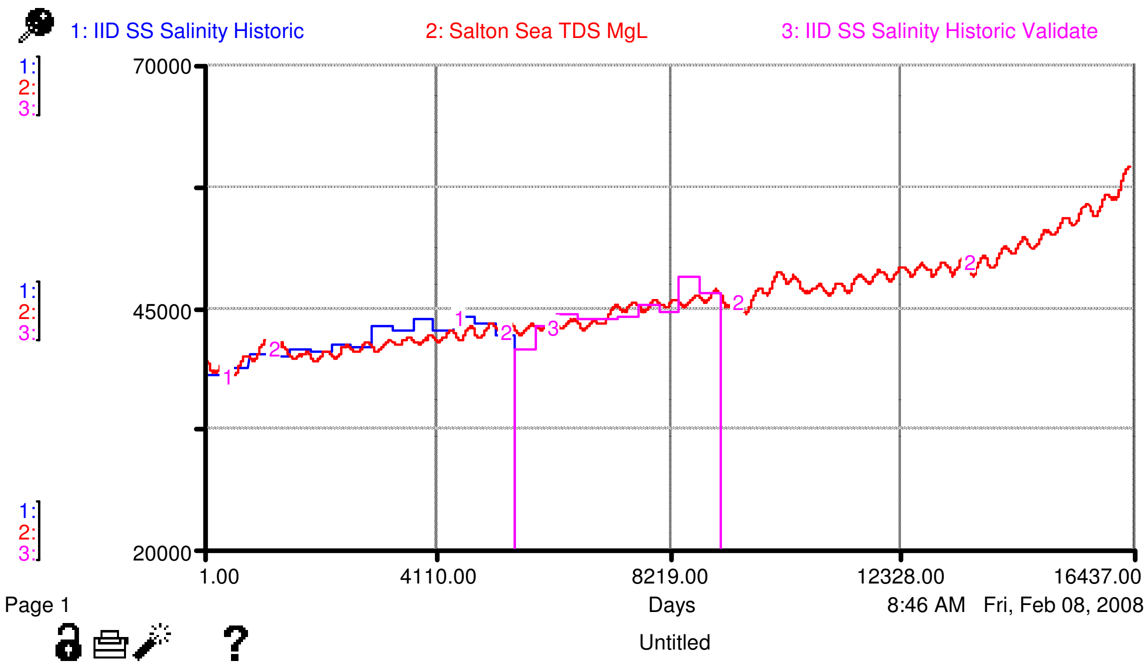

Fig. 6 - Historic salinity based on Total Dissolved Solids (TDS) in mg/L – calibrate (1) and validate (2) versus simulated salinity (3) of the Salton Sea.

interpolation of elevation, surface area, and volume relationships, and thus the calculation of mass balance salt loads.

Model Use

The model simulates effects of changes in water volume and TDS on the Salton Sea, as well as P inflows, as a result of six proposed water management scenarios. The experimental design includes utilizing a mix of seven water management policies in six series of simulations based on: one series representing each of the six water management scenarios: (1) additional New River wetlands, (2) sea impoundment scenarios, (3) agricultural fallowing and lining of the AAC, (4) additional power plants, (5) brine extraction, and (6) one series in which none of the scenarios are implemented [baseline].

Each of the six simulation series consists of 100 replicate, 45-year (1980 through 2024), stochastic simulations with precipitation, Eto, and river flows generated from USGS historical data.

Two strategies were used in modeling the uncertainty in future climate patterns, namely: (strategy 1) the deterministic version of the driving variables in which the historic pattern and number of La Nina and El Nino weather events were preserved, i.e., the past and present as the future, and (strategy 2) the stochastic version of the driving variables in which the pattern of historic La Nina and El Nino weather events was not preserved. In addition, a climate sensitivity analysis was conducted to observe the cumulative effects of plus or minus 10 percent in inflow volumes to the Salton Sea, if any, on sea elevation and salinity, thereby addressing another aspect of future climate uncertainty. These climate analyses were conducted to observe whether or not consistent differences among some of the scenarios, i.e. sea impoundments versus none (policy 2), emerged in spite of climatic variability.

Oneway ANOVAs were performed for each of the six water management scenarios using SPSS version 12.0.1 (SPSS Inc., 2003). Six variables were examined using $\alpha = 0.05$ level of significance. Differences among treatments were determined for each variable using a Bonferroni Multiple Comparison Post Hoc Test. The variables included the following: (1) 'Elevation', a measure of the Salton Sea elevation in feet above sea level (fasl), (2) 'Salinity', measuring Salton Sea salinity (TDS) in milligrams liter^{-1} (mg/L), (3) 'North Elev', measuring the elevation (fasl) of the north, or main, stabilized sea impoundment (4) 'South Elev', measuring the elevation (fasl) of the south, or non-stabilized sea impoundment, (5) ‘North Salinity’, measuring the salinity of the north, or main, stabilized sea impoundment, and (6) ‘South Salinity’, measuring the salinity of the south, or non-stabilized sea impoundment.

Results

The deterministic and stochastic simulation results (baseline) of sea elevation (Figs. 7, 8, & 9), volume (Figs. 10 & 11), surface area in acres (Figs. 12 & 13) and salinity (Figs. 14 & 15) described as milligrams liter^{-1} (mg/L) of TDS can be observed in the respective figures. The simulation results, both deterministic and stochastic, of the precipitation (Figs. A.100, A.101, & A.106) and Eto (Figs. A.102, A.103, & A.107) occurring at the Salton Sea for the 45-year period can be found in Appendix A.

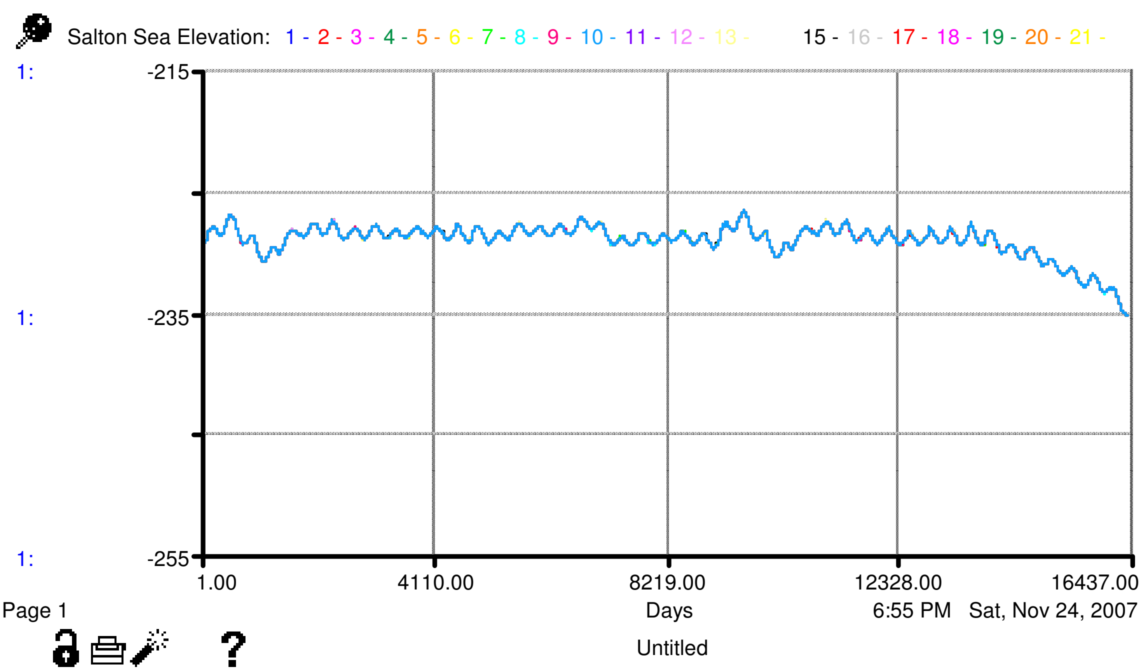

Fig. 7 - Baseline 1 - precipitation and river flow version 1 (deterministic) - simulated Salton Sea elevation (fasl).

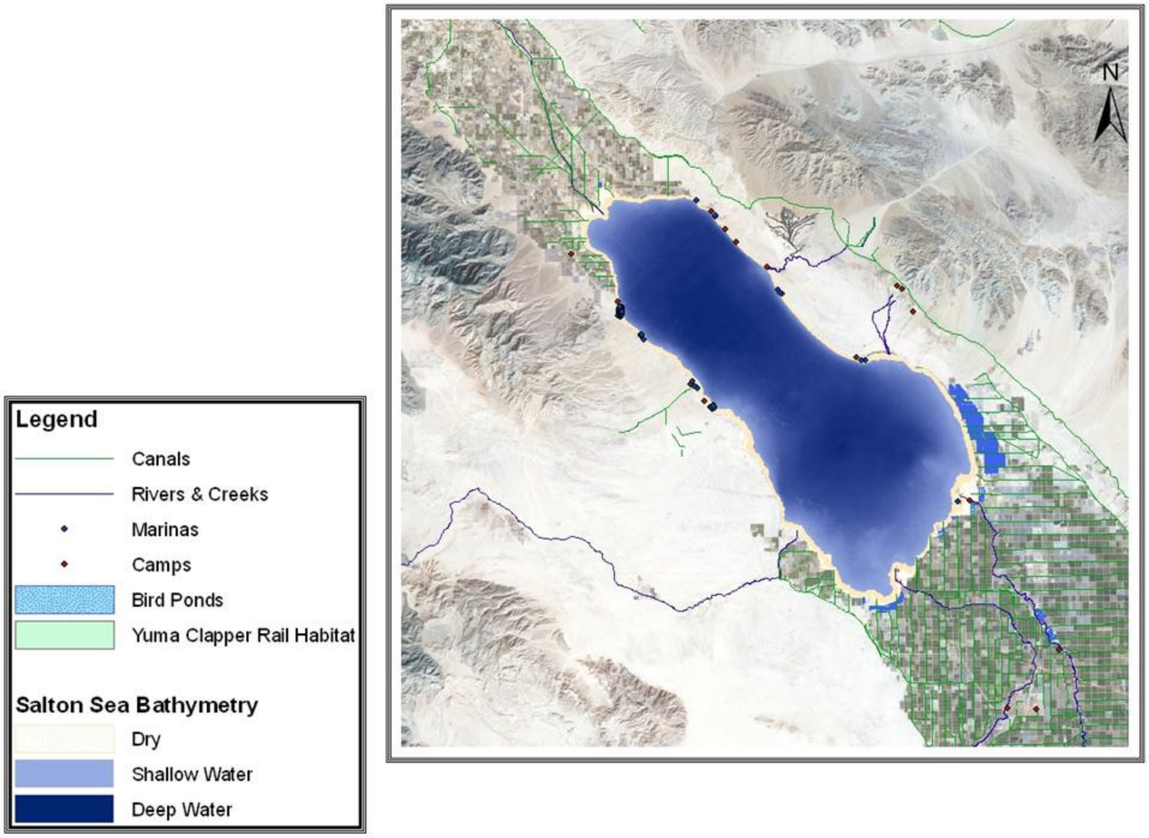

Fig. 8 - Baseline 1 (deterministic version): Salton Sea elevation of -235 fasl at the end of simulation year 2024.

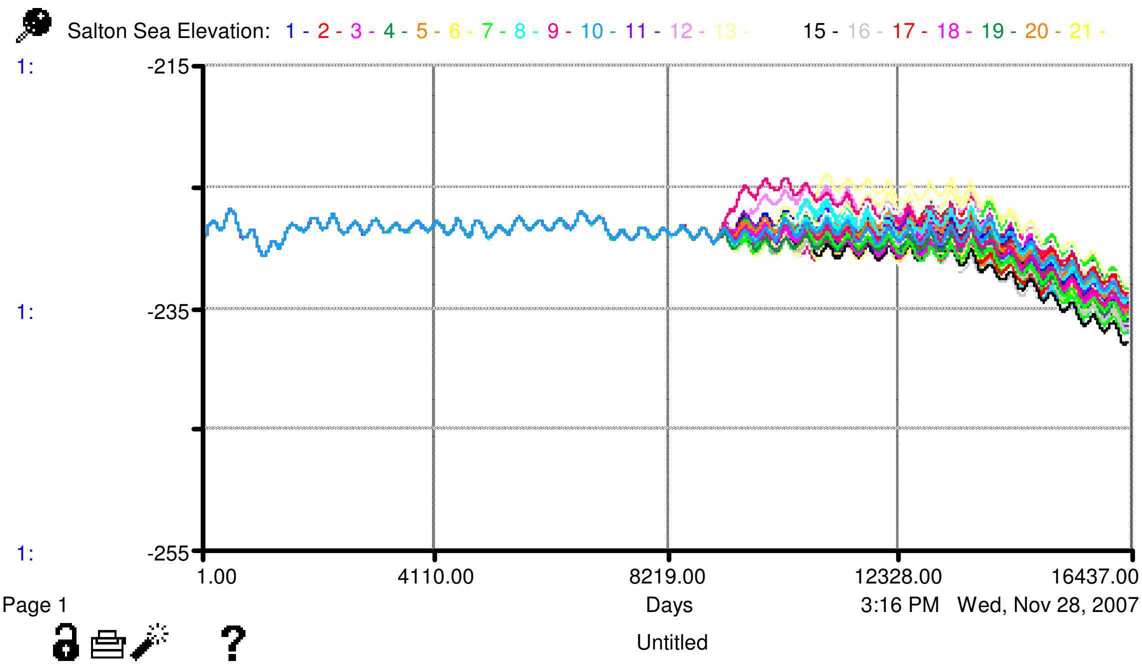

Fig. 9 - Baseline 2 - precipitation and river flow version 2 (stochastic) - simulated Salton Sea elevation (fasl).

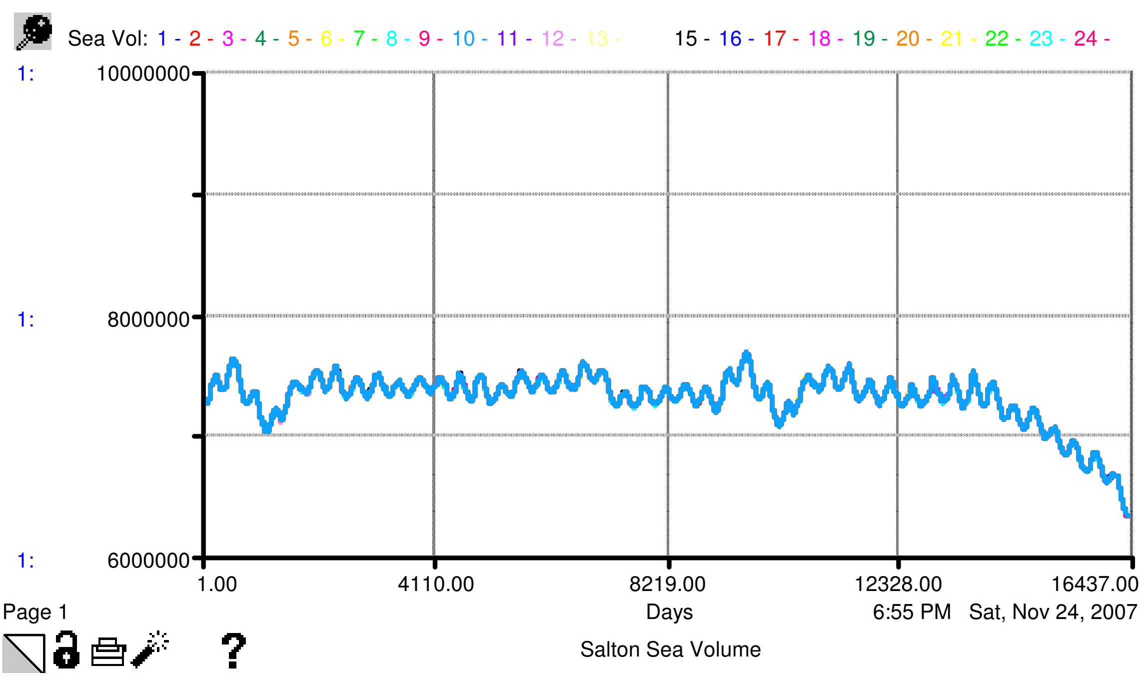

Fig. 10 - Baseline 1 - precipitation and river flow version 1 (deterministic) - simulated Salton Sea volume (acre-feet).

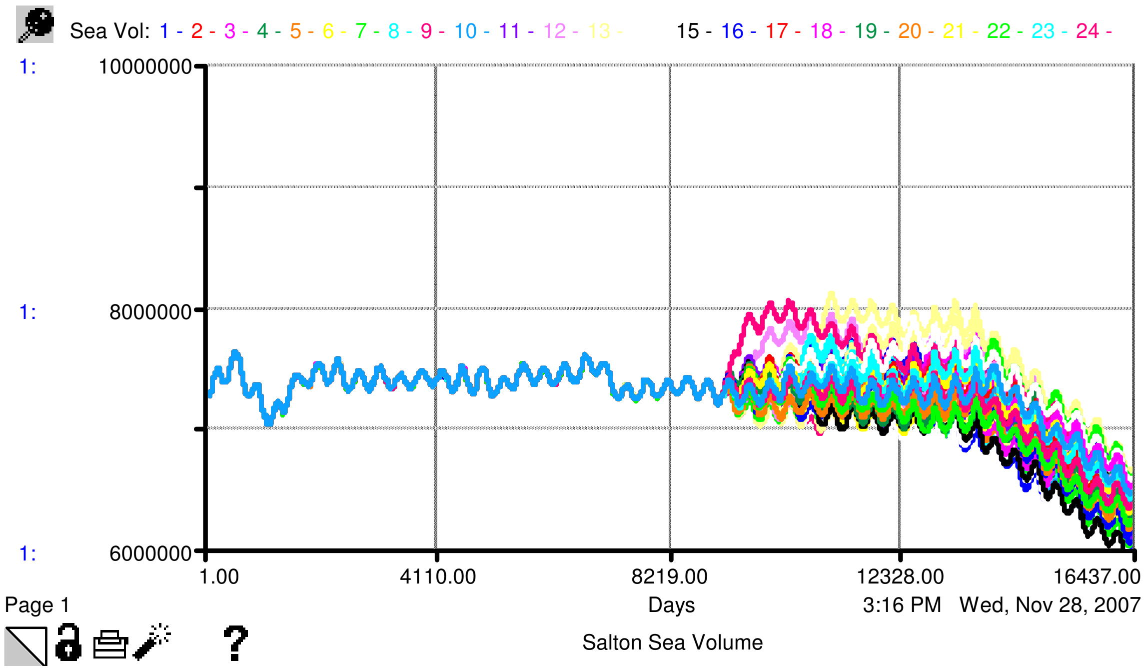

Fig. 11 - Baseline 2 - precipitation and river flow version 2 (stochastic) - simulated Salton Sea volume (acre-feet).

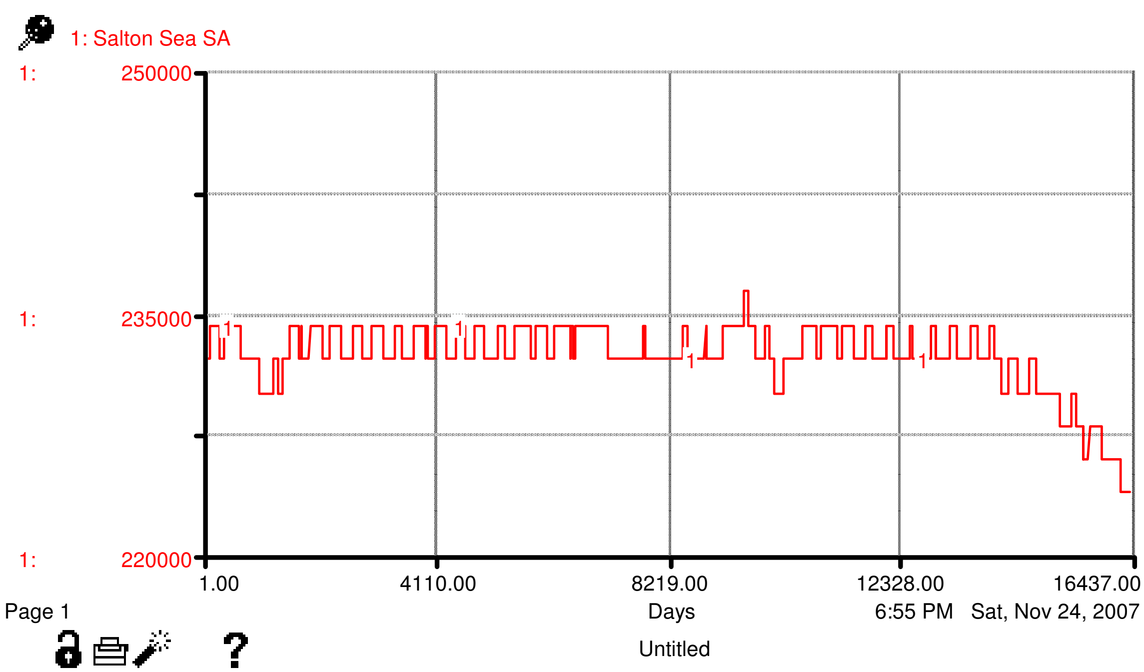

Fig. 12 - Baseline 1 - precipitation and river flow version 1 (deterministic) - simulated Salton Sea surface area (acres).

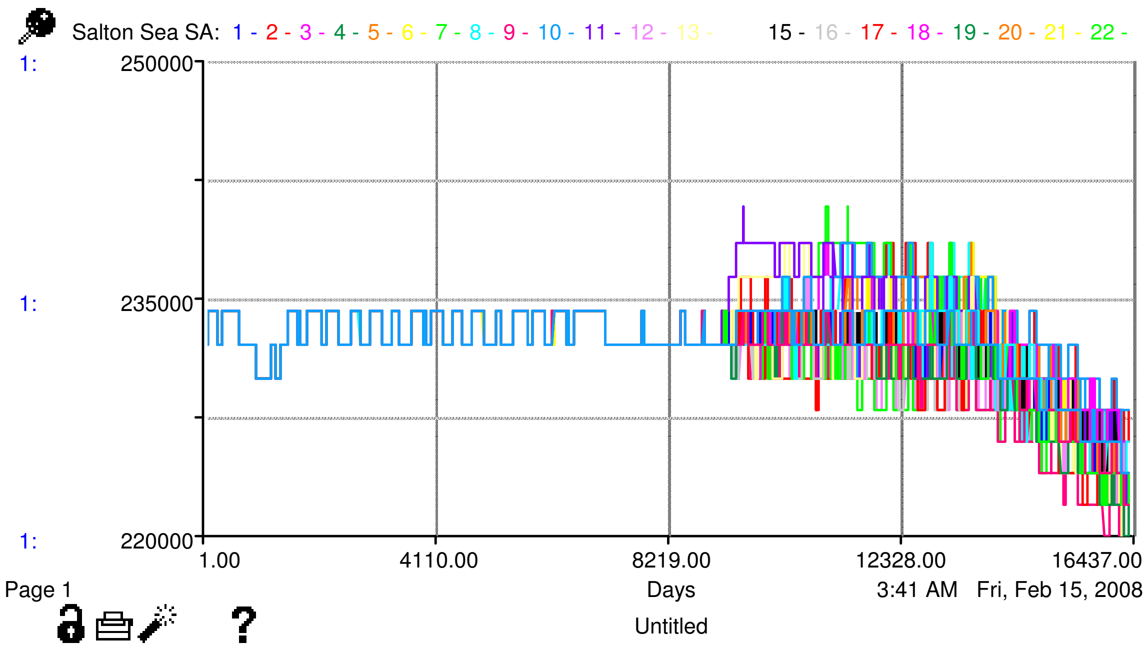

Fig. 13 - Baseline 2 - precipitation and river flow version 2 (stochastic) - simulated Salton Sea surface area (acres).

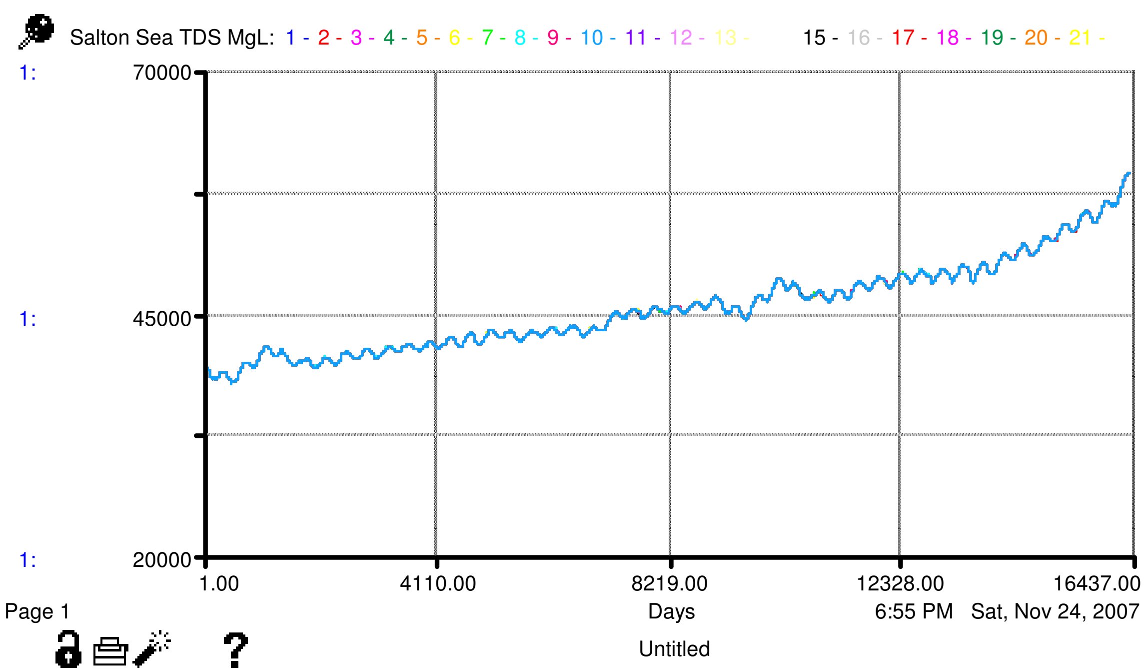

Fig. 14 - Baseline 1 - precipitation and river flow version 1 (deterministic) - simulated Salton Sea salinity (mg/L).

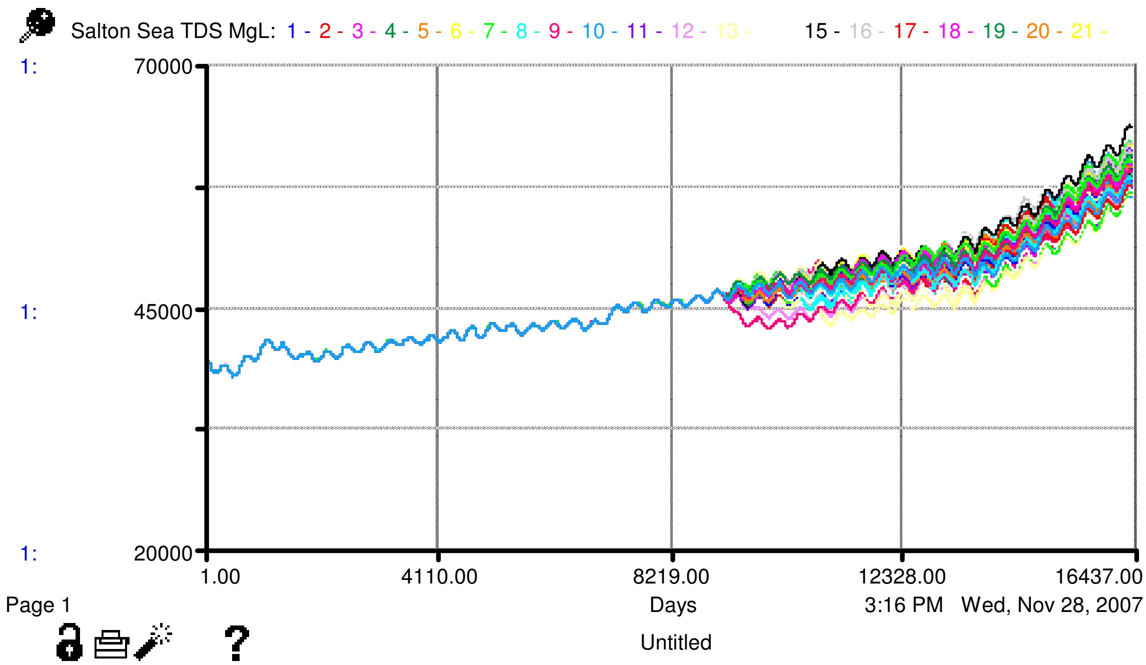

Fig. 15 - Baseline 2 - precipitation and river flow version 2 (stochastic) - simulated Salton Sea salinity (mg/L).

Policy Specific Sub-models and Statistical Results

<u>New River Wetlands (Policy 1)</u>

Two future wetland scenarios were examined using a deterministic driving variable version of the simulation model in terms of the driving variables precipitation, Eto, and river flows: (1) no additional construction of wetlands in addition to the two existing New River wetlands (Baseline) versus (2) a scenario of constructing eight more wetlands for a total of 10 New River wetlands. The simulations were conducted with the construction of 5 Brawley Wetlands and 5 Imperial Wetlands. Although differences in elevation and salinity were less than 1 foot and less than 1,000 ppm, respectively, between the two scenarios; the differences were significant (P<0.05) (Tables B.96 and B.97 in Appendix B). The simulated changes in elevation and salinity by the incorporation of more New River Wetlands can observed by comparing Fig. 7 versus Fig. A.108 (Appendix A), and Fig. 14 versus Fig. A.109 (Appendix A), respectively.

Salton Sea Impoundments (Policy 2)

Three future Salton Sea construct scenarios were examined using both deterministic and stochastic driving variable versions of the simulation model: (1) no construction of impoundments thereby maintaining the sea in its present form (Baseline) versus (2) a scenario of constructing a dike and dividing the sea into two separate impoundments and re-routing river flows to the north impoundment, and (3) a scenario of constructing an impoundment within the sea thereby dividing the sea into two separate impoundments whereby the circumventing portion of the south impoundment dike is placed at an elevation of -234 feet above sea level.

In the deterministic version, the elevation of the north sea at the end of 2024 was -235.38 fasl with a salinity of 59,292 ppm for the baseline version of the model versus -220 fasl and salinities of 7,262 ppm and 15,083 ppm for scenarios 2 and 3, respectively. The elevation of the south impoundment was -232 and -251 fasl with salinities of 101,281 and 213,113 ppm for scenarios 2 and 3, respectively. In the stochastic version, the elevation of the north sea at the end of 2024 was -235.36 fasl with a salinity of 59,025 ppm for the baseline version of the model versus - 220 fasl and salinities of 7,101 ppm and 14,949 ppm for scenarios 2 and 3, respectively. The elevation of the south impoundment was -231.6 and -249.9 fasl with salinities of 98,113 and 194,827 ppm for scenarios 2 and 3, respectively. The north sea was stabilized at -220 fasl under both impoundment scenarios in both the deterministic and stochastic versions of the model.

For both deterministic and stochastic versions of the model, the ANOVA results revealed a statistically significant difference ($P<0.05$) for the elevations and salinities between the baseline scenario versus scenarios 2 and 3. The Bonferroni Multiple Comparisons Post Hoc Tests demonstrated that although there was no significant difference ($P>0.05$) in elevations between impoundment scenarios 2 and 3 for the north sea, the salinities between the two scenarios were significantly different ($P<0.05$) (Tables B.98 through B.103 in Appendix B). The simulated changes in elevation and salinity by the incorporation of the different impoundment scenarios while using deterministic and stochastic future projection schemes can observed by comparing Figs. A.110 through A.129 in Appendix A.

<u>Agricultural Fallowing and Lining of the All American Canal (Policy 3 and 5)</u>

Four scenarios concerning agricultural fallowing and the lining of the All American Canal (AAC) were examined using the deterministic driving variable version of the model: (1) no lining of the AAC but with the implementation of an agricultural fallowing and mitigation strategy (Baseline) versus (2) a scenario of lining the AAC but without the implementation of an agricultural fallowing strategy, (3) a scenario of lining the AAC and including the implementation of agricultural fallowing, but without mitigation water being sent to the sea, and (4) a scenario of lining the AAC and including the implementation of agricultural fallowing with mitigation water being sent to the sea.

Compared to the baseline scenario, scenarios 2, 3, and 4 had significantly higher elevations ($P<0.05$) and significantly lower salinities ($P<0.05$), namely -235.38 fasl and

59,292 ppm TDS versus -220.42 fasl and 43,878 ppm TDS, -225.22 fasl and 47,833 ppm TDS, and -227.25 fasl and 49,681 ppm TDS, respectively (Figs. A.130 through A.136 and Tables B.104 through B.109 in the Appendices). The negative effect of simulated fallowing of farmland on total agricultural acres grown in the IV can be seen in Fig. A.137. The resultant reduction in the All American Canal flow due to fallowing can be seen in Fig. A.138. In turn, the effect of reducing agricultural acres leads to a decrease in agricultural employment as observed in Fig. A.139. The impact of reduced agriculture in the IV on specific sectors within agricultural employment can be observed in Fig. A.140. The effects of reduced agriculture and the impact on total population and water demand increases within the Imperial County and Mexicali, Mexico region, respectively, are also illustrated (Figs. A.141 & A.142).

Power Plants (Policy 4)

Two future power plant scenarios were examined using a deterministic driving variable version of the simulation model: (1) no additional construction of power plants in addition to the two existing SEMPRA and Intergen power plants near Mexicali, Mexico versus (2) a scenario of constructing two more power plants using the same water consumption requirements as the existing. The ANOVA results showed statistically significant ($P<0.05$) differences in elevation and salinity between scenarios 1 and 2, namely -235.38 and -236.13 fasl and 59,292 and 60,437 ppm, respectively (Figs. A.143 through A.145 and Tables B.110 & B.111 in the Appendices).

Waste Water Treatment Facilities (Policy 6)

The Waste Water Treatment Facilities are included as operational in the Baseline scenario and all other scenarios. However, the potential of constructing additional waste water treatment facilities in Mexicali, Mexico was not analyzed in this research, but could easily be included in future research.

Brine Extraction (Policy 7)

Two future brine extraction scenarios were examined using a deterministic driving variable version of the simulation model: (1) no additional construction of evaporation ponds and hence no further brine extraction other than what is currently being done in a pilot project at the Salton Sea versus (2) a scenario of doubling the brine extraction rate due to increasing capacity of evaporation ponds or implementation of an alternative evaporation enhancement method. The ANOVA results showed that there were not statistically significant ($P>0.05$) differences in elevation and salinity between scenarios 1 and 2, namely -235.3819 and -235.3831 fasl and 59,292 and 59,291 ppm, respectively (Figs. A.146 & A.147 and Tables B.112 & B.113 in the Appendices).

Climate Sensitivity Analysis

Three future Salton Sea climate scenarios were examined using both deterministic and stochastic versions of the simulation model: (1) no change in evapotranspiration, precipitation, and river flows (Baseline) versus (2) a scenario of a ten percent increase in precipitation and river flows while holding evapotranspiration constant, and (3) a scenario of a 10 percent decrease in precipitation and river flows while holding evapotranspiration constant. In the climate sensitivity analysis using the deterministic driving variable version of the model, the elevation of the sea at the end of 2024 was -235.38 fasl with a salinity of 59,292 ppm for the baseline version of the model versus -233.38 and -237.09 fasl and salinities of 56,533 and 61,903 ppm for scenarios 2 and 3, respectively (Tables B.114 through B.118 in Appendix B). In the stochastic version of the model the elevation of the sea at the end of 2024 was - 235.36 fasl with a salinity of 59,025 ppm for the baseline version of the model versus - 233.4 and - 237.06 fasl and salinities of 56,335 and 61,598 ppm for scenarios 2 and 3, respectively (Figs. A.148 through A.159 and Tables B.119 through B.121 in the Appendices). For both deterministic and stochastic versions of the model, the ANOVA and Bonferroni Multiple Comparisons Post Hoc Tests results revealed a statistically significant difference ($P<0.05$) for the sea's elevations and salinities between the baseline climate scenario versus climate scenarios 2 and 3, as well as the elevations and salinities between climate scenarios 2 and 3 themselves.

Discussion and Conclusions

Concerning climate futures, a comparison can be made between the two strategies that were used in modeling the uncertainty in future climate projections, namely: (strategy 1) the deterministic version of the driving variables in which the historic pattern and number of La Nina and El Nino weather events were preserved, and (strategy 2) the stochastic version of the driving variables which preserved the number of La Nina and El Nino weather events but not the historic pattern per se. The difference between end simulation baseline mean elevations between the two strategies was less than 3 feet, i.e. range of baseline minimum and maximum (Tables B.114 & B.118 in Appendix B).

The climate sensitivity analyses show that the cumulative effects and change of plus or minus 10 percent in Salton Sea inflows over the period of analysis can have significant effects on sea elevation and salinity, thereby demonstrating the importance of including climate uncertainty in the model. The climate sensitivity analyses were not performed in conjunction with the impoundment scenarios. However, since the conditions of the north or main sea improve overall with the impoundment scenarios in place, one can presume that the climate changes represented in the model will either increase stabilization time or reduce it, but not significantly interfere with the overall trend.

The model projects negative changes in the agricultural employment sector, a loss of 1,747 jobs, due to fallowing of farmland. The model results are similar to the net loss of an estimated 1,330 to 1,400 jobs projected by IID and CH2MHill (2001) depending upon the scenario analyzed (Pick et al., 2003). Pick et al. (2003) states that over 93 percent of job losses associated with Imperial County water diversions for San Diego consumption would pertain to the agricultural sector, representing 2.7 to 2.8 percent of the entire Imperial County workforce (Pick et al., 2003).

The 13 percent of seepage from the All American Canal results in more than the 68,000 acre-feet/year than is estimated by the Colorado River Board of California (1997) and the Salton Sea Ecosystem Restoration Program (2006) and the 368,000 in other conservation measures mentioned by the Colorado River Board of California (1992), perhaps by as much as 1.5 times as much, depending upon the year. As a result, the lining project herein is even more aggressive than the conservation measures and proposition of 23 miles of canal being lined in other studies. Therefore, the canal lining results herein are likely having a larger impact than would other study's plans.

The Mexicali wastewater treatment plants were anticipated to be completed and begin operating in 2006 according to the Salton Sea Ecosystem Restoration Program (2006) and not 2005 as is currently implemented in the model. Likewise, the power plants commenced operations in 2003 (Salton Sea Ecosystem Restoration Program, 2006), not 2005 as implemented in the model. It is unclear whether the power plants began operating at full or reduced capacity. Notably, the Salton Sea Ecosystem Restoration Program (2006) cites annual evaporation as a result of both power plants as approximately 10,667 acre-feet year^{-1}, which is approximately what the model is currently simulating. The conservative assumption of the power plants or waste water treatment plants implementing some sort of TDS removal method (e.g. reverse osmosis) may underestimate the negative impacts of the power plant scenario on the Salton Sea. Irregardless, the construction of two more power plants and associated reduction in New River flows led to a significant decrease in Salton Sea elevation and significant increase in salinity. Therefore any further mitigation measures concerning the Salton Sea should take into consideration the further construction of power plants in the Mexicali, Mexico region.

Although brine extraction lowered salinity, it also lowered the mean elevation of the sea, but neither effect was significant. Therefore, it does not seem that doubling the amount of the brine extraction and processing by the pilot project is sufficient. Brine extraction would have to be further increased to produce a significant effect, and that effect would cause increased evaporation of sea water. The brine extraction alternative might best be utilized in conjunction with the impoundment scenarios, and this could be explored in future research.

The additional construction of eight more New River wetlands produced a counter-intuitive and significant result. Salton Sea salinity was slightly lower and elevation was slightly higher at the end of 2024. However, this is likely due to the retention times in the wetlands and the higher evaporation rate versus what the respective water volume would have had under the evaporation rate in the Salton Sea, and ultimately, the increase in TDS of inflows entering the sea reducing evaporation, via the specific gravity and evaporation relationship, of the overall sea itself. Therefore, the changes in temporal dynamics of the inflows to the Salton Sea may be dampening what might occur at a larger scale had more wetlands been used in the simulations. An increase in the number of constructed wetlands or even a comparison of no wetlands at all in future simulations might further elucidate this relationship.

Compared to the baseline scenario (1), all other scenarios (2, 3, & 4) resulted in increased Salton Sea elevations and reduced salinities. Scenario 2 consisting of lining the AAC, no agricultural fallowing, and no water transfer to San Diego resulted in the most desirable Salton Sea elevation of -220.42 fasl and 43,878 ppm TDS. The problem is that even by lining the canal and without implementing agricultural fallowing, a sea with -220.42 fasl still has a higher salinity of 43,878 ppm TDS compared to the reduced salinity of the main sea in the impoundment scenarios. The scenario in which mitigation water was included for the Salton Sea in tandem with agricultural fallowing (scenario 4) resulted in a decrease in elevation and increase in TDS by the end of 2024 (compared to scenario 3), thus demonstrating the importance of choosing an adequate mitigation method. The fore-mentioned mitigation strategy did however increase elevation and reduce salinity for the years in which it was implemented.

Both of the Salton Sea impoundment scenarios significantly ($P<0.05$) improved (lowered) the salinity in the north or main sea impoundments; compared to the no action alternative (baseline). Further, the elevations of the north or main sea impoundments were stabilized at -220 by the end of 2024, but the salinities between the two scenarios were significantly different ($P<0.05$), more specifically 7,262 ppm and 15,083 ppm, respectively. The salinities of the south impoundments for both impoundment scenarios 2 and 3 were 101,281 ppm and 213,113 ppm, respectively, by the year 2024.

Notably, the model does not currently manage the north impoundment outflows to stabilize salinity levels, and operates by assuming the average salinity of the north or main sea is equal to the salinity of the water volume being discharged to the south impoundment. Another consideration of the salinity levels being simulated herein is that previously precipitated TDS is not being represented as re-dissolving as the sea achieves lower concentrations of TDS. A study by Tetra Tech, Inc. (2003) acknowledged that a slight rise in salinity above the predicted level might occur from the gypsum, or calcium sulfate, which is abundant in the sea sediments. Some of the sea’s precipitates would go back into solution thereby slowing the rate of declining salinity levels (Tetra Tech, Inc., 2003). The temporal dynamics of the salinity reductions demonstrated in the present study may be somewhat optimistic, but the reduction trends themselves are not. It is uncertain how long and to what extent the precipitated and re-dissolving TDS will have in slowing the salinity level reduction on the north or main sea; however, the trends represented by the effects of the impoundments cannot be disputed.

The present study's results pertaining to the baseline trends in elevation and salinity projections for the year 2024 are similar to the results from other studies. For example, the Colorado River Board of California (1992) used sequential cycling of historic conditions as the basis for future inflow conditions, and estimated Salton Sea elevations from approximately -231.4 to -233 fasl and salinity of 67,000 to 79,600 ppm by the year 2020. In another study by Cohen and Hyun (2006), model results showed a Salton Sea elevation of -233.6 fasl and salinity of 60,000 ppm by the year 2018, and approximately -245 fasl and between 90,000 to 100,000 ppm salinity by the year 2024. In a study by Tetra Tech, Inc. (2000), the simulated Salton Sea elevation and salinity results were -234 fasl and 75,000 ppm, respectively, by the year 2030 and assuming reduced future inflow conditions. Fig. A.160 in Appendix A shows more recent Salton Sea salinity levels that are less optimistic than those simulated herein, based on provisional data for the years 2006 and 2007.

Even though the impoundment designs in the present study differed from those in other studies to some degree, the trends were similar. Simulation results by Tetra Tech, Inc. (2000) demonstrated that north and south evaporation ponds, based on reduced inflow conditions, would likely produce a sea with an elevation and salinity of -237 fasl and 46,000 ppm, respectively, by the year 2030. The projected effect of a south evaporation pond based on reduced inflow conditions would result in a sea elevation of -235 fasl and salinity of 47,000 ppm (Tetra Tech, Inc., 2000). A proposal by the Pacific Institute (Weghorst, 2002) would create freshwater impoundments at the northern (2,010 acres) and southern (26,800 acres) ends of the sea, with their surface elevations stabilized at -230 ft with dams constructed at elevation contours of -240 or -245 fasl. By the years 2015 and about 2030, the residual sea's salinity would be 100 g/L and 200 g/L, respectively (U.S.D.I. Salton Sea Science Office, 2002). The residual sea's salinity is similar to the projected salinities of the saline impoundments in the impoundment scenarios (scenarios 2 and 3) in the present study.

Similar to the Pacific Institute's proposal, a proposal by US Filter Corporation (Tetra Tech, Inc., 2003) would create a -240 and -245 elevation dike parallel to the entire shoreline of the sea creating a 40,000-acre ring of water around the sea. Simulation modeling results show that the impoundment would be stabilized at -230 fasl with a salinity level of approximately 3,000 ppm, and about 4,000 ppm within a few months of operation, while the interior sea would shrink and become more hypersaline (Tetra Tech, Inc., 2003). The rapid decrease in salinity within the impoundment lends support to the same rapid decline in salinities under the impoundment scenarios (scenarios 2 and 3) in the present study. Further, simulation model results from a study by the USBR (2003) showed that a mid-sea causeway versus a north-sea causeway could yield a south sea of about 10,000 ppm and 40,000-60,000 ppm, respectively. There is only a 3,000 ppm difference in south sea TDS using a mid-sea causeway in the USBR (2003) study versus the north sea impoundment scenario (2) of a mid-sea causeway in the present study.

The Salton Sea model provides a generalized but straightforward representation of the overall hydraulic system in the LCRB, specifically focusing on the Salton Sea Basin. The existing model illustrates how a system dynamics approach may assist decision-makers in evaluating how the sea may be affected by alternative water management policies, both current and proposed. The results of the Salton Sea model simulations, compared to similar studies, yielded similar future downward trends in sea elevation and upward trends in salinity under the premise that no preventative actions are taken. Should action be taken to stabilize the sea and reduce salinity, the impoundment scenarios demonstrated the most success in the present study.

CHAPTER V

SIMULATED EFFECTS OF PROPOSED WATER MANAGEMENT SCENARIOS ON POPULATIONS OF SELECTED FISH AND AVIAN SPECIES AT THE SALTON SEA

The Salton Sea Model is a stochastic, simulation model representing water flow in the LCRB as it enters the Salton Sea, Colorado River Delta, and the Gulf of California. The model is formulated as a compartment model based on difference equations with a daily time step using STELLA® 8.0 software (High Performance Systems, Inc., Lime, New Hampshire, U.S.A.).

Development, evaluation, and application of the model in order to represent water flow in the Lower Colorado River Basin (LCRB) was conducted to simulate (a) lining the All American Canal with concrete and fallowing farmland in the Imperial Valley, (b) additional power plants in Mexicali, Mexico, (c) additonal wetlands in the New River Wetlands project, (d) extracting brine from the sea, (e) dividing the Salton Sea into north and south impoundments, and (f) the resulting effects on the population dynamics of selected fish and avian species at the Salton Sea. In this chapter, the hypothesis that the proposed action will not significantly impact selected populations of fish and avian species was tested for each future policy scenario.

Background Information

The terminal lake ecosystem of the Salton Sea is located in the southeastern corner of California, only 30 miles from the U.S.-Mexico border (Tetra Tech, Inc., 2000). The Salton Sea is a major hydrologic element of the Lower Colorado River Basin (LCRB) and is considered important to the economic, social, and biological values of the region. However, it is suffering marked degradation as a consequence of human activity and although efforts to rehabilitate the Salton Sea ecosystem have been underway for more than a decade, they have had little success. "Once one of the biologically richest and most diverse areas in North America, the lower Colorado River region now is one of the most degraded ecosystems in the United States"- Daniel Anderson (Vincent, 2000).

Increased water demands of cities like San Diego, California and Mexicali, Mexico have resulted in declining levels of aquifers, increased nutrient and contaminant loading of streams in the LCRB, in turn decreasing freshwater inflows to the Salton Sea. Plans to meet the increasing residential and industrial water demands include lining the All American Canal with concrete to reduce losses as water is moved from the Colorado River to San Diego, fallowing farmland in the Imperial Valley to reduce agricultural water use, and diverting water from the New River to operate the newly constructed power plants in Mexicali, Mexico. Plans to improve water quality include increasing the number of wetlands through the New River Wetlands Project and extracting brine (salt) from the Salton Sea.

On January 1, 2002, the Department of the Interior cut off California's access to any Colorado River above its 4.4 million acre-foot share (4.4 Plan). One of those hardest hit was the water agency that serves San Diego, which will lose nearly half of the water it has used in the past (McKinnon, 2002). Since current California usage is about 5.2 million acre-feet, which would mean losing 800,000 acre-feet of water per year, enough to support around 5 million people (Spillman, 2002). A water transfer from Imperial Valley to San Diego was proposed as a result, and raises serious concerns regarding the future ecosystem health of the Salton Sea. Under the water transfer, a multibillion-dollar plan was agreed upon to move up to 300,000 acre-feet of water annually from Imperial Valley farms to homes in San Diego and the Coachella Valley (Spillman, 2003). The water transfer impacts agricultural production in one of the richest agricultural centers in the nation, one that provides much of the country's wintertime vegetables (Polakovic, 2001).

Commercial agriculture plays a large role in maintaining the Salton Sea, as it is sustained primarily by agricultural drainage from the Imperial, Coachella, and Mexicali valleys, with contributions from municipal effluent and storm water runoff (SSA, 2001a). Since the sea is largely replenished by agricultural runoff, it will shrink as inflows are reduced from about 1.3 million-acre-feet annually to 1 million acre-feet (Spillman, 2003). Major diversions of freshwater from the sea would cause the salinity to rise to levels unsuitable for the successful reproduction of fish and major invertebrate species. The loss of fish and major invertebrate life in the sea would have detrimental impacts on some piscivorous avifauna (Black, 1983).

The sea is an important resource for migrating and resident birds, a significant fishery, the site of a national wildlife refuge, and a place of special concern because of the large loss of wetlands experienced in both California and Mexico (BRSSA, 2000). Since about 1780, 91 percent of California's wetlands have disappeared, making the Salton Sea increasingly important as habitat for wetland species (SSA, 2001f). Some scientists have called the Salton Sea "California's crown jewel of avian biodiversity" and at one time the most productive fishery in the world (SSA, 2001b). Scientists are concerned that even a small increase in salinity could affect fish reproduction and survival and the birds that feed on them (SSA, 2001c). For instance, Type C avian botulism struck in 1996, killing 15-20 percent of the western white pelican population and more than 1,000 endangered brown pelicans, the largest reported die-off of an endangered species. In 1998, 7.6 million fish died in the Salton Sea from oxygen depletion due to algae (SSA, 2001d). Today, all fish in the Salton Sea are under stress due to the combination of elevated salinity, accelerated eutrophication, and dramatic water quality fluctuations that result in lethal water quality events (Costa-Pierce, 1999).

The Salton Sea Reclamation Act (SSRA) of 1998 directed that studies be conducted to evaluate the feasibility of possible actions to allow continued uses at the Salton Sea (USBR, 2003). The SSRA established the Salton Sea Restoration Project to maintain and restore ecological and socioeconomic values of the Salton Sea to the local and regional human community and to the biological resources dependent upon the sea (Tetra Tech, Inc., 2000). The Salton Sea is a "proving ground" that tests our resolve and ingenuity in resolving water management issues both on behalf of society and for the conservation of biological resources (SSA, 2001e).

Modeling involving the Salton Sea has been employed in previous studies, but only on a very limited basis (Tetra Tech, Inc., 2000). There is a recognized need for integrated (physical, biological, social) models (Groffman and Likens, 1994) but relatively few truly integrated quantitative models exist (Carpenter et al., 1999), and none currently exist for the LCRB, with regard to the Salton Sea. A more credible approach would be to address the Salton Sea in the context of a complex agricultural-ecological system, where both natural factors such as climate and elevation and anthropogenic factors such as land use impact the sea (Cohen et al., 1999). These complex issues have been incorporated into a simulation model in an attempt to create a more effective tool for understanding and managing the complex environmental and natural resource problems facing the LCRB.

Methods

Salton Sea Model Description

The model consists of groups of sub-models representing the dynamics of the following: (I) water volume, (II) water quality in the sea, (III) the population dynamics of selected fish species in, and (IV) avian species around the sea (III and IV are the focus of this chapter). The Salton Sea model consists of several sub-models representing the dynamics of: (1) Lower Colorado River Basin, (2) Salton Sea Water Volume, (3) Salton Sea Evapotranspiration, (4) Salton Sea Precipitation, (5) Salton Sea TDS mass fluxes,

(6) Salton Sea Water Balance, (7) Salton Sea River Inflows, (8) Salton Sea Exposed Sea Bottom, (9) Agricultural Sector, (10) Human Population Growth, and (11) Salton Sea Ecology. The Salton Sea Ecology sub-models are the focus of the present chapter. The Salton Sea Ecology sub-models represent the avian populations of the California Brown Pelican and American White Pelican, as well as the fish populations of Mozambique Mouthbrooder Tilapia, Sargo, Croaker, and Orangemouth Corvina. Another sub-model determines fish kill event frequency and strength based on a set of established indices. A general description of the water quality and water volume sub-models and their parameterization follows, while a more detailed description can be found in Chapter IV.

The model simulates the flow of water into the LCRB from entry points on the Colorado River (near Palo Verde Dam), the Gila River (near Dome, Arizona), and the White Water River (near Mecca, California). Water also enters the system via precipitation and from the Mexicali Aquifer (implicitly) and from the Coachella Valley Aquifer. Water diverted for agricultural use and the subsequent runoff in the Coachella Valley is adjusted to reflect water pumped from the aquifer. The model also accounts for miscellaneous agricultural drain runoff and subsurface runoff to the sea. The Alamo River, New River, White Water River, and Coachella Agricultural Drainage empty directly into the sea.

Water leaves the system via evaporation and transpiration from the Salton Sea, the Brawley and Imperial Wetlands, and implicitly via evapotranspiration from the farmlands in the Coachella Valley and the Imperial Valley; as agricultural runoff is adjusted to reflect water use by crops. Water is also lost via evaporation from the power plants near Mexicali, Mexico (MX) and sea brine extraction. A portion of the Colorado River water is diverted into the All American Canal (AAC) and flows to the Imperial and Coachella Valleys and also the Gila Canal which diverts water to Arizona. Seepage from the AAC is captured as groundwater recharge in the Mexicali Aquifer. Water that is not diverted from the Colorado River flows to the Gulf of California.

Fish Sub-models

The fish sub-models represent the Salton Sea populations of Mozambique Mouthbrooder Tilapia (*Oreochromis mossambicus*), Sargo (*Anisotremus davidsoni)*, Croaker (*Bairdiella icistia*), and Orangemouth Corvina (*Cynoscion xanthulus)*. The common names of these fish will hereafter be used in the text to refer to these species. The Mozambique Mouthbrooder Tilapia will hereafter be referred to as Tilapia.

The four species of fish in the analyses were chosen based on their prevalence in the Salton Sea and their ability to tolerate the high salinities. By the early 1980's Tilapia became the dominant fish species in the sea and the most important prey for the increasing numbers of piscivorous birds. In 1982-83, the combined recreational catch of Sargo, Corvina, Croaker, and Tilapia averaged over 1.5 fish/hour; making it one of the highest yielding sport fisheries in the nation (Black, 1983). In one study conducted in 1999; Tilapia were the most dominant fish by number and weight at the Salton Sea, followed by Croaker, Corvina, and Sargo; while all other species were of marginal importance in numbers and weight (Riedel et al., 2001).

Since the prey species of these four fish species are also able to survive high salinities; the assumption was made that the limiting factor at present is salinity and not food availability. For instance, one of the major invertebrate species, the Pileworm, can survive salinities up to 80,000 ppm TDS and is considered to be a major forage item for the various sportfish (Black, 1983). Of the four fish species, only the Tilapia can potentially survive longer than the Pileworm. Tilipia could find other prey resources such as copepods that are still available to them at higher salinities, i.e. 90-100,000 mg/L (Cohen and Hyun, 2006), than the Pileworm can tolerate (Table B.122 in Appendix B). Tilipia adults feed mainly on detritus, but as opportunists eat plankton and periphyton when available (Trewavas, 1983). Moreover, the success of Tilapias as widely dispersed and abundant fishes appears to be due mainly to (a) their use of plant food, including phytoplankton, which is rarely limiting, with detritus and some other foods, i.e., invertebrates, zooplankton, as a reserve, and (b) their flexibility in growth rate and maturation size according to the prevailing environmental conditions (Beveridge and McAndrew, 2000). Irregardless, a further increase in Salton Sea salinity may have adverse effects on fish reproduction, recruitment, and growth (Riedel et al., 2001).

Due to the lack of life table demographic parameters concerning these species in the scientific literature, a Leslie-matrix age cohort model was not utilized. Instead, the age classes were pooled into one population that had holistic natality and mortality rates. The structure of the fish sub-models was similar for each fish species and the equations were the following:

$$T_{t+1} = T_t + (R_t - M_t) * \Delta t \qquad (30)$$

where:

T_t = number of Tilapia in the Salton Sea at time t,

R_t = recruitment (number of individuals recruited during day t),

M_t = mortality (number of individuals dying during day t),

Δt = 1 day, and

$R_t = rr * rs_t * T_t$ (31)

where:

rr = per capita recruitment rate (number of individuals recruited per individual day^{-1}),

rs_t = effect of salinity on recruitment during day t (unitless index between 0 and 1).

$C_{t+1} = C_t + (R_t – M_t) * \Delta t$ (32)

where:

C_t = number of Croaker in the Salton Sea at time t,

R_t = recruitment (number of individuals recruited during day t),

M_t = mortality (number of individuals dying during day t),

Δt = 1 day, and

$R_t = rr * rs_t * C_t$ (33)

where:

rr = per capita recruitment rate (number of individuals recruited per individual day^{-1}),

rs_t = effect of salinity on recruitment during day t (unitless index between 0 and 1).

$S_{t+1} = S_t + (R_t – M_t) * \Delta t$ (34)

where:

S_t = number of Sargo in the Salton Sea at time t,

R_t = recruitment (number of individuals recruited during day t),

M_t = mortality (number of individuals dying during day t),

Δt = 1 day, and

$$R_t = rr * rs_t * S_t \tag{35}$$

where:

rr = per capita recruitment rate (number of individuals recruited per individual day^{-1}),

rs_t = effect of salinity on recruitment during day t (unitless index between 0 and 1).

$$OC_{t+1} = OC_t + (R_t - M_t) * \Delta t \tag{36}$$

where:

OC_t = number of Orangemouth Corvina in the Salton Sea at time t,

R_t = recruitment (number of individuals recruited during day t),

M_t = mortality (number of individuals dying during day t),

Δt = 1 day, and

$$R_t = rr * rs_t * OC_t \tag{37}$$

where:

rr = per capita recruitment rate (number of individuals recruited per individual day^{-1}),

rs_t = effect of salinity on recruitment during day t (unitless index between 0 and 1).

The sub-models representing Tilapia and Sargo populations are illustrated in Figs. A.161 and A.162, respectively, in Appendix A. A schematic of the biotic and abiotic interactions currently represented in the Salton Sea Model can be found in Fig. 16.

It is important to note that both recruitment and stock size are difficult to measure in Tilapias and other tropical species that reproduce over an extended period of time and are difficult to age. Consequently, there are no Tilapia stocks for which a stock recruitment relationship has been determined (Beveridge and McAndrew, 2000). In

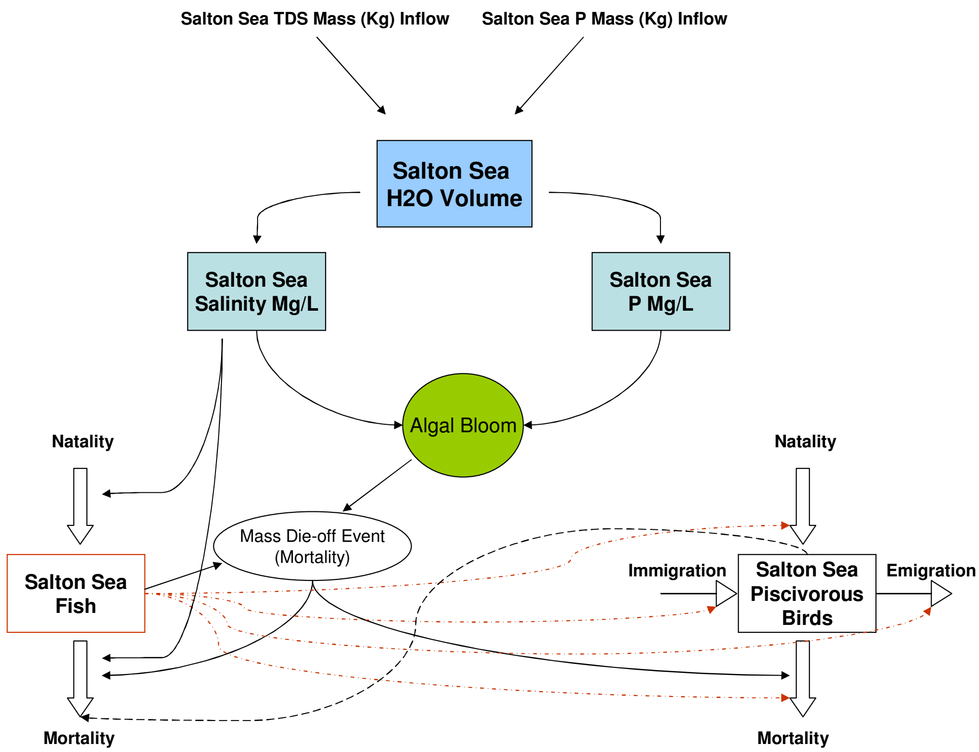

Fig. 16 - Salton Sea water volume, water quality, and biota relationships in the model.

spite of these shortcomings, the hypotheses posed earlier can still presumably be tested because differences in the population trends, resulting from salinity changes under the proposed scenarios, can still be generated and quantified. Setmire (2000) notes that during the past decade, die-offs are more numerous and consist of several million fish; and this information, albeit general, can still serve as a measure of model validation.

Fish Kill Index Sub-model

The Fish Kill Index sub-model takes into account average monthly temperatures, Phosphorous (P), and salinity (TDS) levels at the Salton Sea and implicit effect on dissolved oxygen, fish parasite load and physiological stress. Monthly average ambient temperature data were obtained from CIMIS weather station data located at Salton City. Increases in water temperature cause decreases in the solubility of oxygen and simultaneous increases in the oxidation rate, creating a greater oxygen demand on a reduced supply (Dunne and Leopold, 1978; Cohen and Hyun, 2006). Alternatively, cold water temperatures can stress Tilapia and brine shrimp, leading to die-offs during the winter months (Cohen and Hyun, 2006).

The effects of environmental factors like temperature and salinity can be magnified when fish are already stressed from parasite infestations. In a study by Kuperman et al. (2001) high parasite loads in fish at the Salton Sea were found to cause severe damage to gills and skin which may lead to respiration and osmoregulation problems causing fish suffocation and death. The peak periods for *Amyloodinium ocellatum* infestation were July and August at water temperatures of 39-41ºC, and October and November at water temperatures of 21-24 ºC for *Ambiphrya ameiuri* (Kuperman et al., 2001).

The changing P levels from the Alamo and New River inflows at their outlets to the sea were used in measuring the probability of a fish kill event. Phosphorous was chosen for analysis over other nutrients due to the fact that is by far the potential limiting nutrient in the Salton Sea, and responsible for stimulating primary productivity in the sea (Setmire, 2000). The principle is that by reducing P one may reduce algal blooms and potential anoxic conditions produced thereafter that can lead to fish and bird die-offs.

The algal bloom fish-kill events in the model are based on two auxiliary variables, both of which affect the frequency and strength of fish die-off events, assuming a direct correlation with sea TDS levels, sea river inflow P levels, and ambient temperature (Tables B.123 to B.125, respectively, in Appendix B). More specifically, the probability of a fish kill event occurring was based on measures of the following indices: 1) increased P plus increased TDS plus increased ambient air temperature and 2) increased TDS plus low ambient air temperature. If the conditions are met, then a Monte Carlo procedure is applied to select if a fish kill occurs or not. The Monte Carlo procedure, namely the 'Random Chance' and 'Random Chance P' stochastic variables, accounts for more finite resolution factors like wind and resultant turbidity, sea over-turn, initial P content within the Salton Sea, BOD levels, and Salton Sea ammonia levels.

The strength of a fish kill event was determined by the auxiliary variable 'Overall Fish Kill Index' and based on a scale of 1 to 4, representing the following: 1) a fish kill of a small magnitude equal to 0.1 to 0.5% of the population, 2) a fish kill of a medium magnitude equal to 0.6 to 0.8% of the population, 3) a fish kill of a large magnitude equal to 0.9 to 2% of the population, 4) a fish kill of a severe magnitude equal to 2.1 to 10% of the population (Fig. A.163 in Appendix A).

Avian Sub-models

The avian sub-models represent populations of the California Brown Pelican (CBP), *Pelecanus occidentalis californicus*, and American White Pelican (AWP), *Pelecanus erythrorhynchos*. Pelicans (*Pelecanidae*) are primarily fish eaters, requiring up to 4 pounds of fish a day (USFWS, 1995). In order to test the fore-mentioned hypotheses, one must rely on fish eating avian species, as some prey resources may not disappear with increased salinities, i.e. brine shrimp, brine flies, polychaete worms, rotifers, and copepods that are common in the sea. According to Black (1983) the increasing salinity at the Salton Sea may not impact usage by certain groups of birds. However, the disappearance of all fish from the sea would have detrimental impacts on fish-eating birds, e.g., herons, pelicans, and egrets (Black, 1983). Also, much like the miner's canary in the coal mine, the pelican is an early warning system of danger for many other species of wildlife (Brown and Guravich, 1983).

Due to the lack of life table demographic parameters concerning the CBP and AWP species, similar to the fish sub-models, one overall population natality and mortality rate was applied for individual species. The sub-model representing the Salton Sea AWP and CBP populations is illustrated in Fig. A.164 in Appendix A. The avian sub-models representing the total AWP and CBP pelican populations (e.g., Fig. A.165 in Appendix A), population other than the one at the Salton Sea, are designed to experience recruitment based on constant natality and mortality rates. The structure utilized for the outlying Salton Sea avian population sub-models resembles that of the *B.I.D.E.* model:

$Nt{+}1 = Nt + B - D + I - E$ also written as $\Delta N = B - D + I - E$

(Δ means "change") (38)

where:

B = total number of births,

D = total number of deaths,

I = total number of immigrants, and

E = total number of emigrants.

More specifically, the California Brown Pelican submodel equations:

$CBP_{t+1} = CBP_t + (R_t - M_t) * \Delta t$ (Δ means "change") (39)

where:

CBP_t = entire population of California Brown Pelicans,

R_t = recruitment (number of CBPs day^{-1}),

M_t = natural mortality (number CBPs day^{-1}),

Δt = 1 day, and

$SSCBP_{t+1} = SSCBP_t + B_t - D_t + I_t - E_t$

also written as $\Delta N = B - D + I - E$ (Δ means "change") (40)

where:

$D_t = m_t + ae_t$, and

$I_t = ic_t * if_t$

where:

$SSCBP_t$ = Salton Sea population of California Brown Pelicans (a proportion of CBP),

B_t = total number of births,

D_t = total number of deaths,

I_t = total number of immigrants,

E_t = total number of emigrants,

m_t = natural mortality (number of CBPs day^{-1}),

ae_t = avian epizootics brought on by fish kills induce by increasing salinities,

ic_t = daily immigration rate to Salton Sea (proportion of population day^{-1}), and

if_t = effect of food availability on immigration rate (coefficient that adjusts daily immigration (ic) as a function of Salton Sea fish population).

Similarly, the American White Pelican submodel equations:

$$AWP_{t+1} = AWP_t + (R_t - M_t) * \Delta t \quad (41)$$

where:

AWP_t = entire population of American White Pelicans,

R_t = recruitment (number of AWPs day^{-1}),

M_t = natural mortality (number of AWPs day^{-1}), and

Δt = 1 day.

$$SSAWP_{t+1} = SSAWP_t + B_t - D_t + I_t - E_t$$

also written as $\Delta N = B - D + I - E$ (Δ means "change") (42)

where:

$D_t = m_t + ae_t$, and

$I_t = ic_t * if_t$

where:

$SSAWP_t$ = Salton Sea population of American White Pelicans (a proportion of AWP),

B_t = total number of births,

D_t = total number of deaths,

I_t = total number of immigrants,

E_t = total number of emigrants,

m_t = natural mortality (number of AWPs day^{-1}),

ae_t = avian epizootics brought on by fish kills induce by increasing salinities,

ic_t = daily immigration rate to Salton Sea (proportion of population day^{-1}), and

if_t = effect of food availability on immigration rate (coefficient that adjusts daily immigration (ic) as a function of Salton Sea fish population).

It is assumed that neither of the pelican populations ever reaches carrying capacity, and thus K is absent from the avian sub-models. Density independent factors have and continue to play a large negative role on the populations of these pelican species. In 1970, the U.S. Fish and Wildlife Service listed the brown pelican as an endangered species, meaning it was in danger of extinction through all or a significant portion of its range (USFWS, 1995) while the continental White Pelican population appears to be stabilizing (Evans and Knopf, 1993). However, in Florida pelican deaths from fishhook and line entanglements result in mortalities that are estimated to be in the thousands (Brown and Guravich, 1983).

The outlying Salton Sea avian population sub-models assume an annual immigration of the entire sea pelican population, while the emigration rate is modified positively or negatively as sea prey' (fish) populations decrease or increase, respectively. The assumption is made that the populations of both pelican species do not reside year-round at the Salton Sea, even though some years pelicans may be present year-round in small numbers. Also, the mortality rates for the Salton Sea avian sub-models are constants, with an additive mortality based on bird epizootics that arise from fish die-offs caused by fish kill events. The idea of a separate natural relative death rate, considered a constant, and death rate due to fish kill events is patterned after Flake et al. (2003).

The Salton Sea avian sub-models also assume that breeding is absent at the sea. The California Brown Pelican (CBP) is a common summer and fall visitor (mainly May through mid-November) and rare (but increasing) through the winter at the sea (Patten et al., 2003). A coastal species, the CBP is a common post-breeding visitor to the Salton Sea. Few CBPs are present on the sea from mid-January through much of April (Patten et al., 2003). Although the CBP was first reported breeding at the sea in 1996 and subsequently in 1997 and 1998, no young were successfully raised (Shields, 2002). The Salton Sea is also an important wintering site for the American White Pelican (AWP), harboring a substantial percentage of the world population (Patten et al., 2003). The AWP formerly bred at the Salton Sea year-round (Cooper, 2004). Based on Shields (2002) and Cooper (2004) it is assumed that Pelican natality is equal to 0 at the sea.

The avian sub-models do not incorporate intra-specific or inter-specific competition. Johnsgard (1993) noted that there is probably relatively little competition between the Brown Pelican and the AWP, considering their very differing foraging behaviors and generally non-overlapping distributions. Although, there may be cases of competition between the two pelican species, as their distributions do overlap at the Salton Sea. In the model it is assumed that these interactions are not currently a significant factor in the CBP and AWP population dynamics based on Johnsgard (1993).

Parameterization

<u>Fish Parameters</u>

The decreased reproduction and deaths due to salinity tolerance limitations and increased mass die-off events of fish, brought about by a number of hypothesized factors, are assumed to be correlated to salinity increases and represented as such in the Salton Sea Model. One algal species, *Prymnesium* sp., has been associated with fish kills elsewhere and experiments show that it becomes more abundant as salt levels rise from 44 parts per thousand (ppt) to 48 ppt or higher (Cohn, 2000).

The fish sub-models are designed to experience recruitment based on natality and mortality rates that are modified positively or negatively as salinity decreases or increases respectively (Table B.126 in Appendix B). It is currently assumed that fish intra-specific and inter-specific competition and predation and algal bloom induced die-offs due to phosphates are incorporated in the constant mortality rates applied in the model. Mortality is a function of a constant morality rate, but Pelican consumption of Tilapia is accounted for separately. Pelican consumption of Tilapia is dependent upon the number of pelicans at the Salton Sea and the number of other fish species and respective populations that are available to the pelicans. Tilapia mortality increases as the number of other fish species' populations decline via prey switching by the pelicans (Tables B.127 and B.128 in Appendix B).

A study by Reidel et al. (2003) found that Salton Sea fish grew faster, but had shorter life spans than con-specifics elsewhere and Salton Sea species of 5 decades ago. Adaptation to the high salinity and low dissolved oxygen of the Salton Sea may have come at a cost of reduced longevity for fish (Riedel et al., 2001). In the Salton Sea the Tilapia species has a life span of approximately two years (Setmire, 2000). Recent studies indicate that there may be about 90 million Tilapia in the Salton Sea (Setmire, 2000), making up the majority of the sportfish in the sea and have the highest salinity tolerance (Costa-Pierce, 1999). Tilapia total instantaneous mortality for the 1995 cohort was estimated to be 0.40, but no sufficient data allowed mortality estimates for any other age class (Riedel et al., 2001). Based on Setmire (2000) and Riedel et al. (2003), a mortality rate of 0.15, not including pelican predation, and an initial population of 90 x 10^6 for Tilapia is assumed in the Salton Sea Model. Instantaneous mortality rates (fishing and natural causes) for *O. mossambicus,* range from 0.4 to 3.1 year^{-1} depending upon the water body conditions; while population growth rates ranged from 0.26 year^{-1} and 0.52 year^{-1} (Beveridge and McAndrew, 2000). Tilapia can become sexually mature at about three months of age (Neil, 1964). Salton Sea Tilapia can reproduce six to eight times annually (Riedel et al., 2002; Cohen and Hyun, 2006). A conservative natality rate of 3.5 was assumed for Tilapia since many can spawn several times a year. Based on the life history data, the algorithm (EXP((LOGN(3.5+1))/4)-1) was used to account for four reproductive bouts year^{-1} in the model.

Gulf croaker from the Salton Sea have been reported to mature in 1-2 years, spawn in May and early June, and have a life span of up to eight years (Riedel et al., 2001). The Atlantic croaker also has a maximum age of about two years although most fish live only to about age 1 with a total annual mortality rate of about 96% (White and Chittenden, 1976). According to White and Chittenden (1976), no reliable method of age determination exists and reproduction has not been intensively studied for the Croaker. In terms of fecundity, Hildebrand and Cable (1930) reported 180,000 uniform size eggs, but Hansen (1970) reported only 41,200 eggs (Lassuy, 1983). Information concerning Sargo (Riedel et al., 2001) and the reproductive biology of the Orangemouth corvina (Prentice, 1987) is lacking in the scientific literature. The nearest approximation of fecundity for Orangemouth corvina in the literature concerned induced spawning statistics. The artificially induced spawning study resulted in the following: 2.6 kg females producing 624,000 eggs of which 69.6% hatched (Prentice, 1987).

In the absence of more specific data for Croaker, Sargo, and Corvina, assumptions had to be made concerning their life-history parameters. It was assumed that Corvina, being the most successful top carnivore in the Salton Sea (Riedel et al., 2001), would have the slowest population growth rate and less of a difference between natality and morality rates compared to the other fish species represented in the model. Specific parameters for all species utilized in the fish sub-models are listed in Table B.129 in Appendix B.

Avian Parameters

Pelicans are opportunistic, selecting prey on the basis of availability (Evans and Knopf, 1993). The Salton Sea avian sub-model assumes a fairly equal distribution in the proportion of the fish species in the pelican diet. It is assumed the Tilapia compose a higher proportion (0.3) of the diet for both pelican species, due to their large numbers at the Salton Sea, compared to that of the Corvina (0.1) (Table B.129 in Appendix B). One study found that Tilapia, in terms of total prey mass, constituted 85% of diet in Eastern White Pelicans (n=65) (Johnsgard, 1993). The model also assumes that the average pelican during its stay at the Salton Sea consumes 1,000 fish annually, assuming they stay 3 months on average, and eat larger fish, i.e. not 1,000 fish each weighing 10 grams. One study indicated that a CBP captive adult consumed an average of 590 g fish/day

(Shields, 2002). Evans and Knopf (1993) state that breeding adult AWPs eat an estimated 1.8 kg/d, therefore non-breeding AWPs would eat significantly less.

The southern California population of brown pelicans today is estimated at 4,500 to 5,000 breeding pairs (USFWS, 1995). Cooper (2004) estimated California Brown Pelican population was 50,000 pairs for California and Mexico during the 1970s and 1980s. In California, the breeding population of the CBP increased dramatically during the 1980s and has remained fairly stable since the early 1990s with an estimated 50,000-51,000 breeding pairs (Shields, 2002). Based on the literature, the model assumes an initial CBP population of 33,000 individuals. Shuford et al. (2000) reported that in 1990 the maximum number of CBPs counted at various locations (in August) around the Salton Sea was more than 2,000. Since the mid-1990s, single-day counts have reached 2,000 individuals (Shuford et al., 2000) and probably exceed 3,000 (Patten et al., 2003). Based on these reports, the initial population of the Salton Sea avian sub-model representing outlying Pelican populations was assumed to be 10% (3,000 individuals) of the total CBP population.

The AWP population consists of 120,000+ birds, all in the U.S. and Canada; with an estimated 30% of the population wintering at the Salton Sea (Cooper, 2004). Therefore, an assumption of the initial total AWP population equal to 140,000 individuals was made, more specifically, 25,000 individuals in the Salton Sea population and 115,000 individuals in the outlying population. A 10% emigration rate, + or – 10% (stochastic), was assumed for the outlying avian population sub-models (both species), based on the small degree of annual variation in Salton Sea pelican populations.

Specific demographic data (life span, sex ratio, age-specific birth and death rates, philopatry) needed to calculate life table and population dynamics are lacking for the brown pelican (Shields, 2002) and for the AWP. No direct measure of lifetime reproductive success was available; however, effective reproductive lifespan was listed as 4-7 years for the Brown Pelican (Shields, 2002). Band recoveries of Brown Pelicans suggest that only 30% survive their first year, fewer than 2% survive beyond 10 years, with a maximum life span of 43 years (Shields, 2002). Pelicans have a fairly long maximum life span for birds, in another study a recovered banded bird was determined to be 25 years old (Brown and Guravich, 1983). Breeding success varies widely among years and colonies, mainly in response to variation in food availability. Productivity averages about 1 fledgling nest^{-1} (Schreiber, 1979; Shields, 2002) and one clutch per breeding season (Shields, 2002). Schreiber (1979) reported annual variations in productivity ranging from 0.33 to 1.7 young fledged per nest, with an overall eight-year mean of 0.93 young per nest (376 nests) (Johnsgard, 1993). Since populations of both pelican species have remained fairly stable, a small growth rate of 0.005 was assumed. Although the fore-mentioned growth rate may be conservative for the AWP, as Breeding Bird Survey data indicated continental population increases at rate of 5.3% year^{-1} from 1966 to 1991 (Evans and Knopf, 1993). Mortality and natality rates were assumed to be fairly low for both species ($r = 0.105$, mortality rate = 0.1) (Table B.130 in Appendix B).

A previous study, Cohn (2000), has identified a bacterium in the guts of Tilapia that may be a vital link to the spread of avian botulism in pelicans and other fish-eating birds. The bacterium, *Vibrio alginolyticus,* is thought to weaken the fish and create anoxic conditions in their guts that allow botulism spores to develop (Cohn, 2000). Since botulism is an accumulative sickness, it seems reasonable to assume that the pelican's mortality rate at the sea is proportional to the number of sick fish ingested (Flake et al., 2003), or in the case of the present study, additive mortality based on the size of the fish die-off event (Table B.131 in Appendix B).

Model Evaluation

The ability of the model to simulate the fluctuations in water volume and salinities (TDS) in the Salton Sea, as well as levels of Phosphorous (P) entering the Salton Sea was assessed based on historic elevation, river inflows, TDS, and P levels. To verify that simulated water flows adequately represented historic flows, a series of 15-year simulations was run for calibration purposes, driving the model with the water flows recorded at pertinent USGS gage stations from 1980 to 1994. The ability of the model to simulate the fluctuations in water flows and Salton Sea elevation was validated for the years 1995 to 2004.

Similar to the calibration exercise, the model was driven using the historic water flow data and precipitation and evapotranspiration (Eto) data obtained from the respective USGS gage stations and CIMIS weather stations. The model simulated historic Salton Sea elevations to within 1 foot, -228 fasl (simulated) & -229 fasl (historic), and maintained patterns of seasonality. Based on the observed versus simulated Salton Sea elevation data, the model has an error rate of less than one percent and regarded as reasonable. Similarly, based on the observed versus simulated Salton

Sea TDS data the model had an error rate of about 7 percent and therefore regarded as reasonable. Chapter IV provides a detailed description of model calibration and validation results.

The calibration and validation of the fish kill events, fish population dynamics, and bird population dynamics at the Salton Sea are based on an incomplete historic record in the form of anecdotal information from the scientific literature. Further, comparisons of the number of birds lost to disease for different events and times at the Salton Sea are based on subjective evaluations (Friend, 2002), and the same may be said for fish losses. The Salton Sea population dynamics of selected avian and fish species responded to the changes in water quality thresholds appropriately in terms of overall trends in frequency and strengths of die-offs and populations of birds and fish at the sea (Figs. A.166 through A.184 in Appendix A). However, there were some notable differences in the biotic responses due to changes in the water volume and water quality sub-models as compared to available historic data. The frequency, strength and numbers of die-off events were similar but the dates did not correspond as well, due to the lack of wind speed and direction, dissolved oxygen, and generalized incorporation of water temperature data in the model. Importantly, the general trend of increases in avian and fish mortality mass die-off events were similar to those observed in the past, as reported by Shuford (1999). For example, in 1996 a major outbreak of Type C avian botulism occurred and total confirmed bird deaths was over 14,000 (8,500+ AWP and 1,100+ CBP) (Roberts, 1997). In 1999, 7.6 million Tilapia and croakers die from oxygen being depleted due to algae in Salton Sea (SSA, 2001d). Also, in the year 2000, 413 CBPs and

2 million fish, mostly Tilapia, died (Dungan, 2002), while Setmire (2000) listed die-off events totaling 14,003,700 Tilapia, 317,100 Croaker, and 2,200 Corvina.

Model Use

The experimental design included utilizing a mix of six water management policies in six series of simulations based on: one series representing each of the following water management scenarios: (1) additional New River wetlands, (2) Salton Sea impoundment scenarios, (3) agricultural fallowing and lining of the AAC, (4) additional power plants, (5) brine extraction, and (6) one series in which none of the scenarios are implemented, i.e. baseline (Figures 166 through 183 in Appendix). Each of the six simulation series consists of 100 replicate, 45-year (1980 through 2024), stochastic simulations with precipitation, Eto, and river flows generated from USGS historical data. Two strategies were used in modeling the uncertainty in future climate patterns, namely: (strategy 1) the deterministic version of the driving variables in which the historic pattern and number of La Nina and El Nino weather events were preserved, i.e., the past and present as the future, and (strategy 2) the stochastic version of the driving variables in which the pattern of historic La Nina and El Nino weather events was not preserved. In addition, a climate sensitivity analysis was conducted to observe the cumulative effects of plus or minus 10 percent in inflow volumes to the Salton Sea, if any, on sea elevation and salinity, thereby addressing another aspect of future climate uncertainty. Sensitivity analyses were also conducted for fish, avian, and fish kill sub-models by including variance to address the uncertainty of parameterization data to ensure that the model was operating appropriately and to observe the effects, if any, on overall trends.

Oneway ANOVAs were performed for each of the six water management scenarios using SPSS version 12.0.1 (SPSS Inc., 2003). Fourteen dependent variables were examined using $\alpha = 0.05$ level of significance. Differences among treatments were determined for each variable of analysis using a Bonferroni Multiple Comparison Post Hoc Test (Tables B.132 through B.149 in Appendix B). The variables of analysis included the following: (1) ‘FishKilled’, a measure of the number of fish killed, (2) ‘FishKillPercent’, measuring the magnitude of fish kills as a percent of the fish population killed, (3) ‘DeathAlgalFishKills’, measuring the difference in the number of fish kills, (4) ‘DeathAlgalFishKillIndex’, measuring the difference in the number of fish kills before applying the Monte Carlo procedure, (5) ‘Tilapia’, measuring the size of the Tilapia population at the end of the simulations, (6) ‘Sargo’, measuring the size of the Sargo population at the end of the simulations, (7) ‘Corvina’, measuring the size of the Corvina population at the end of the simulations, (8) ‘Bairdiella’, measuring the size of the Bairdiella population at the end of the simulations, (9) ‘AWPPopSize’ or ‘TotalAWP’, measuring the size of the Continental AWP population at the end of the simulations, (10) ‘CBPPopSize’ or ‘TotalCBP’, measuring the size of the Continental CBP population at the end of the simulations, (11) ‘SSAWP’, measuring the size of the sea AWP population at the end of the simulations, (12) ‘SSCBP’, measuring the size of the sea CBP population at the end of the simulations, (13) ‘AWPpop’, measuring the size of the continental AWP population minus the sea AWP population at the end of the simulations, (14) ‘CBPpop’, measuring the size of the continental CBP population minus the sea CBP population at the end of the simulations.

Results

The variable ‘Climate Futures’ was adjusted (+) & (-) 10%, and the simulation results analyzed. Three future Salton Sea climate scenarios were examined using both deterministic and stochastic versions of the driving variables (strategy 1 and 2, respectively) of the simulation model: (1) no change in evaporation, precipitation, and river flows (Baseline) versus (2) a scenario of a ten percent increase in precipitation and river flows while holding evaporation and evapotranspiration constant, and (3) a scenario of a 10 percent decrease in precipitation and river flows while holding evaporation and evapotranspiration constant.

The ANOVA and Bonferroni Multiple Comparisons Post Hoc Tests results revealed a statistically significant difference ($P<0.05$) for the elevations and salinities between the baseline climate scenario versus climate scenarios 2 and 3 (Tables B.115 through B.117 in Appendix B) for both Strategies 1 and 2. Tilapia population changes were not significant ($P>0.05$) but the Sargo, Bairdiella, and Corvina fish populations at the end of the simulations increased significantly ($P<0.05$) comparing the baseline scenario (scenario 1) to climate scenario 2 (+10%) under strategy 1. Comparing the baseline scenario to climate scenario 3 (-10%) Sargo and Corvina fish populations showed a significant increase while Bairdiella populations did not and Tilapia populations showed a significant increase. The number of fish killed ‘FishKilled’ and magnitude of fish kills ‘FishKillPercent’ was higher in both climate scenarios 2 and 3, but ANOVAs revealed the difference was not significant from baseline scenario 1 (Figs. A.184 through A.187 in Appendix A). The difference in the number of fish kills (variables ‘DeathAlgalFishKills’ and ‘DeathAlgalFishKillIndex’) between all three scenarios was statistically significant according to the ANOVAs. The Bonferroni Multiple Comparisons Post Hoc Tests revealed that fish kills significantly decreased between baseline and climate scenario 2 but did not significantly increase between baseline and climate scenario 3. Differences between the end simulation Pelican populations were not significant for any of the climate scenario comparisons.

Based on the ANOVAs and Bonferroni Multiple Comparisons Post Hoc Tests, all four of the fish populations at the end of the simulations increased significantly comparing the baseline scenario (scenario 1) to climate scenario 2 (+10%) of the strategy 2 version of the model. Comparing the baseline scenario to climate scenario 3 (-10%) Tilapia, Sargo, and Corvina fish populations showed a significant decrease, and while Bairdiella populations decreased, the difference was not significant. The number of fish killed ‘FishKilled’ and magnitude of fish kills ‘FishKillPercent’ were lower in climate scenario 2 and higher in climate scenario 3, but Bonferroni Multiple Comparisons Post Hoc Tests revealed the differences were not significant from baseline scenario 1. The difference in the number of fish kills (variables ‘DeathAlgalFishKills’ and ‘DeathAlgalFishKillIndex’) between all three scenarios was statistically significant according to the ANOVAs. However, the Bonferroni Multiple Comparisons Post Hoc Tests revealed that fish kills were not significantly decreased between baseline and climate scenario2. Likewise, fish kills were not significantly increased between baseline and climate scenario3. Differences between the end simulation Pelican populations under strategy 2 were not significant for any of the climate scenario comparisons.

Fish Kill Sensitivity Analysis

Fish kill sensitivity analyses revealed that a (+) or (-) 10 percent change in the initial algal bloom parameter resulted in a significant change under both Strategies 1 and 2 (Tables B.131 through B.136 in Appendix B). Specifically, an increase of (+) 10 percent caused a fish kill number increase from 65.98 baseline to 74.94 or fish kill number decrease to 56.4 ('DeathAlgalFishKills') under strategy 1. In the stochastic version of the model, the fish kill number baseline of 65.54 increased to 75.67 in scenario 2 and decreased to 58.56 in scenario 3. Similar changes also occurred for the variable 'DeathAlgalFishKillIndex'. Under strategy 1, the number of fish killed and cumulative fish kill percentage ('FishKilled' and 'FishKillPercent', respectively) showed an increase between scenarios 1 and 2, but decreased between scenarios 1 and 3, although these changes were not significant as demonstrated by the Bonferroni Multiple Comparisons Post Hoc Tests. A similar trend occurred under strategy 2, however, the decrease in the cumulative fish kill percentage ('FishKillPercent') between scenarios 1 and 3 was significant (P=0.002). Regardless of the fore-mentioned significant differences in fish kill and algal bloom variables, the end of simulation populations for the individual fish and pelican species did not exhibit significant differences between the baseline scenario and scenarios 2 and 3 (Figs. A.188 through A.191 in Appendix A).

Fish Sensitivity Analysis

Sensitivity analyses of Tilapia, Sargo, Bairdiella, and Corvina revealed that a (+) or (-) 10 percent change in the initial fish reproduction parameter (r) resulted in significant changes in end simulation populations under both Strategies 1 and 2 (Tables B.137 through B.142 in Appendix B). The Bonferroni Multiple Comparisons Post Hoc Tests for strategy 1 revealed a significant increase in fish populations of all four species for scenarios 1 versus 2 and a significant decrease between scenarios 1 versus 3. However, under strategy 2 only Bairdiella showed this significant relationship for scenarios 1 versus 2 and 1 versus 3, while Tilapia and Sargo showed a significant change in populations for scenarios 1 versus 2 and Corvina populations did not show a significant difference for any scenario (Figs. A.192 and A.193 in Appendix A). Notably though, elevations and salinities were significantly different in the stochastic version of the model for scenarios 1 versus 2, but not 1 versus 3, and this likely resulted in some of the differences between the significance of the relationships between Strategies 1 and 2. The end simulation AWP and CBP populations did not show any significant differences.

Pelican Sensitivity Analysis

Pelican sensitivity analyses revealed that a (+) or (-) 10 percent change in the initial pelican population parameter for both species resulted in a significant increase or decrease, respectively, in the end of simulation pelican populations for both the strategy 1 (Figs. A.194 through A.201 in Appendix A) and strategy 2 versions of the model (Tables B.143 through B.148 in Appendix B). In strategy 1 for example, overall AWP and CBP (‘TotalAWP’ and ‘TotalCBP’) end of simulation populations were 73,451 and

25,700, respectively, for baseline scenarios versus 117,548 and 40,500 in scenario 2 and 48,072 and 16,702 in scenario 3. Populations of AWP and CBP (‘SSAWP’ and ‘SSCBP’) at the Salton Sea, or the subpopulation that immigrates and emigrates, for the baseline scenario were 18,570 and 3,427, respectively, compared to 25,303 and 4,548 in scenario 2 and 12,071 and 2,211 in scenario 3. The variables ‘AWPpop’ and ‘CBPpop’ represented the pelican subpopulation that does not immigrate or emigrate to and from the sea. The pelican sensitivity results from strategy 2 were very similar to those of the fore-mentioned deterministic strategy 1. Notably, the impacts on fish populations due to the changes in the pelican populations were not significantly different from the baseline scenario.

Wetlands (Policy 1)

Two future wetland scenarios were examined under strategy 1: (1) no additional construction of wetlands in addition to the two existing New River wetlands (Baseline) versus (2) a scenario of constructing eight more wetlands for a total of 10 New River wetlands. The differences in elevation and salinity between the two scenarios were significant ($P<0.05$). The frequency and strength of algal blooms and the number of fish killed were not significantly different ($P>0.05$) (Tables B.97 and B.98 in Appendix B). However, even though there was an increase in all four fish populations, specifically Tilapia, Sargo, Bairdiella, and Corvina; only Sargo and Corvina populations showed a significant ($P<0.05$) increase at the end of 2024 (Fig. A.202 in Appendix A). Both the AWP and CBP populations showed an increase, but the increase was not significant ($P>0.05$).

Salton Sea Impoundments (Policy 2)

Three future Salton Sea construct scenarios were examined using both Strategies 1 and 2: (1) no construction of impoundments thereby maintaining the sea in its present form (Baseline) versus (2) a scenario of constructing a dike and dividing the sea into two separate impoundments and re-routing river flows to the north impoundment, and (3) a scenario of constructing an impoundment within the sea thereby dividing the sea into two separate impoundments whereby the circumventing portion of the south impoundment dike is placed at an elevation of -234 feet above sea level.

For both Strategies 1 and 2, the ANOVA results revealed a statistically significant difference ($P<0.05$) for the elevations and salinities between the baseline scenario versus scenarios 2 and 3. Under strategy 1 the elevation of the north sea at the end of 2024 was -235.38 fasl with a salinity of 59,292 ppm for the baseline version of the model versus -220 fasl and salinities of 7,262 ppm and 15,083 ppm for scenarios 2 and 3, respectively. Under strategy 2 the elevation of the north sea at the end of 2024 was -235.36 fasl with a salinity of 59,025 ppm for the baseline version of the model versus - 220 fasl and salinities of 7,101 ppm and 14,949 ppm for scenarios 2 and 3, respectively. The north sea was stabilized at -220 fasl under both impoundment scenarios for both Strategies 1 and 2. The Bonferroni Multiple Comparisons Post Hoc Tests demonstrated that although there was no significant difference ($P>0.05$) in elevations between impoundment scenarios 2 and 3 for the north sea, the salinities between the two scenarios were significantly different ($P<0.05$).

The differences in end simulation fish (variables 'Tilapia', 'Sargo', 'Bairdiella', 'Corvina') and bird (variables 'AWPPopSize' and 'CBPPopSize') populations showed a significant increase ($P<0.05$) between the baseline scenario versus both impoundment scenarios 2 and 3 (Tables B.99 through B.104 in Appendix B). The frequency and strength of algal blooms ('FishKillPercent', 'DeathAlgalFishKills', and 'DeathAlgalFishKillIndex', respectively) and the number of fish killed ('FishKilled') significantly decreased ($P<0.05$) between the baseline scenario versus both impoundment scenarios 2 and 3 (Figs. 17 through 19). Notably, there were not significant differences ($P>0.05$) concerning the variables measuring the frequency and strength of algal blooms and the number of fish killed between the impoundment scenarios 2 and 3 themselves. The differences between the end simulation population estimates between impoundment scenarios 2 and 3 were only significant ($P>0.05$) for the fish species Bairdiella and Sargo and not for either of the bird species (Figs. A.203 through A.214 in Appendix A and Figs. 20 through 28). The stochastic version (strategy 2) showed similar results with the only exception being that the differences between the end simulation population estimates pertaining to impoundment scenarios 2 and 3 themselves were not significantly different ($P>0.05$) for any of the fish and bird species.

Power Plants (Policy 4)

Two future power plant scenarios were examined using strategy 1 of the simulation model: (1) no additional construction of power plants in addition to the two existing SEMPRA and Intergen power plants near Mexicali, MX versus (2) a scenario of

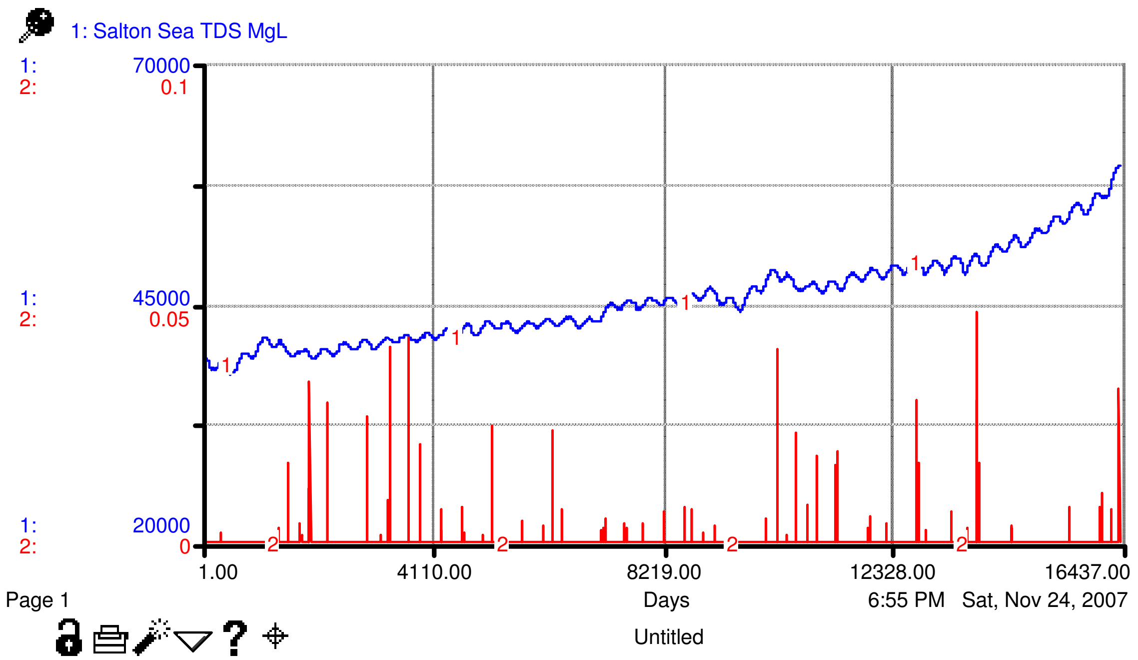

Fig. 17 - Baseline 1 (strategy 1): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

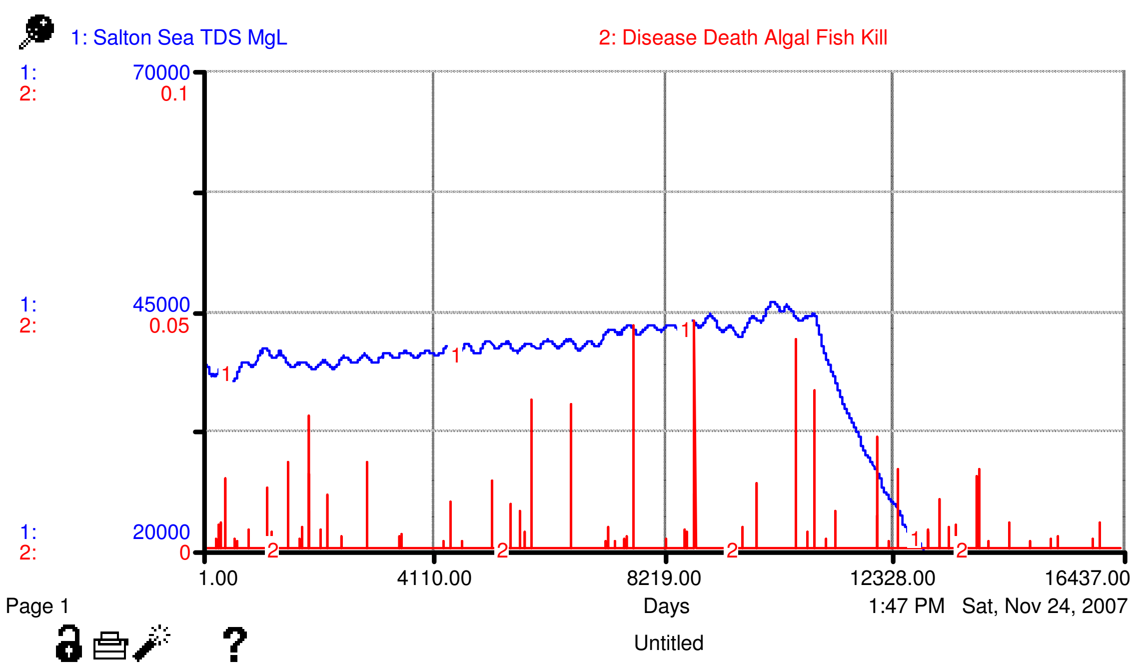

Fig. 18 - Salton Sea impoundment design 1 (strategy 1): north impoundment salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

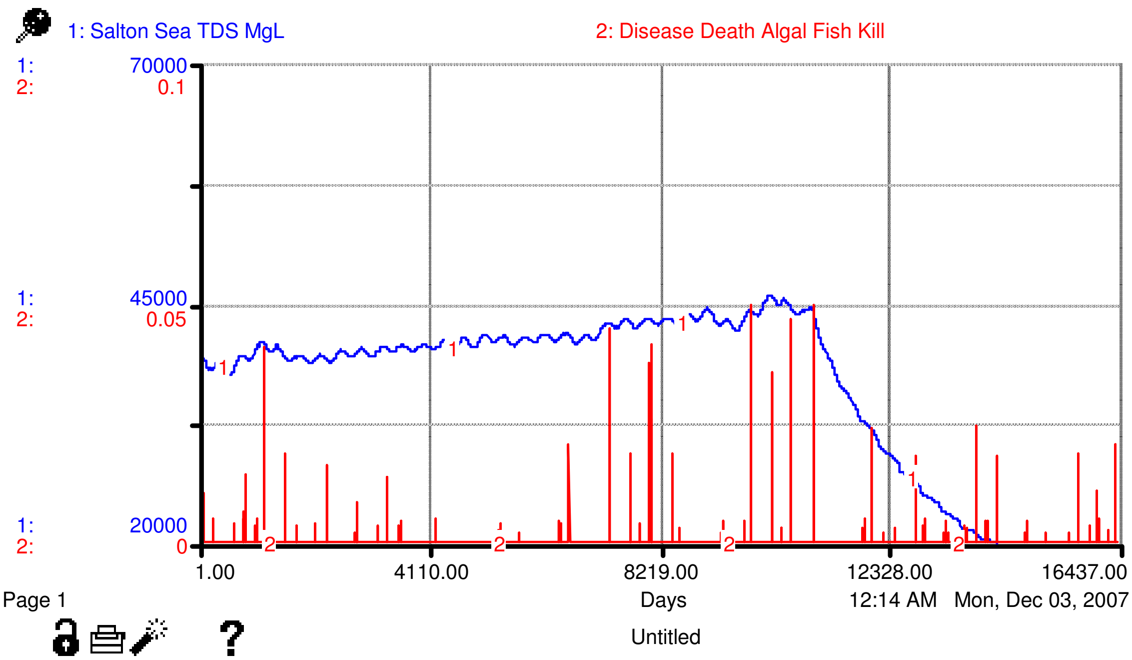

Fig. 19 - Salton Sea impoundment design 2 (strategy 1): north impoundment salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

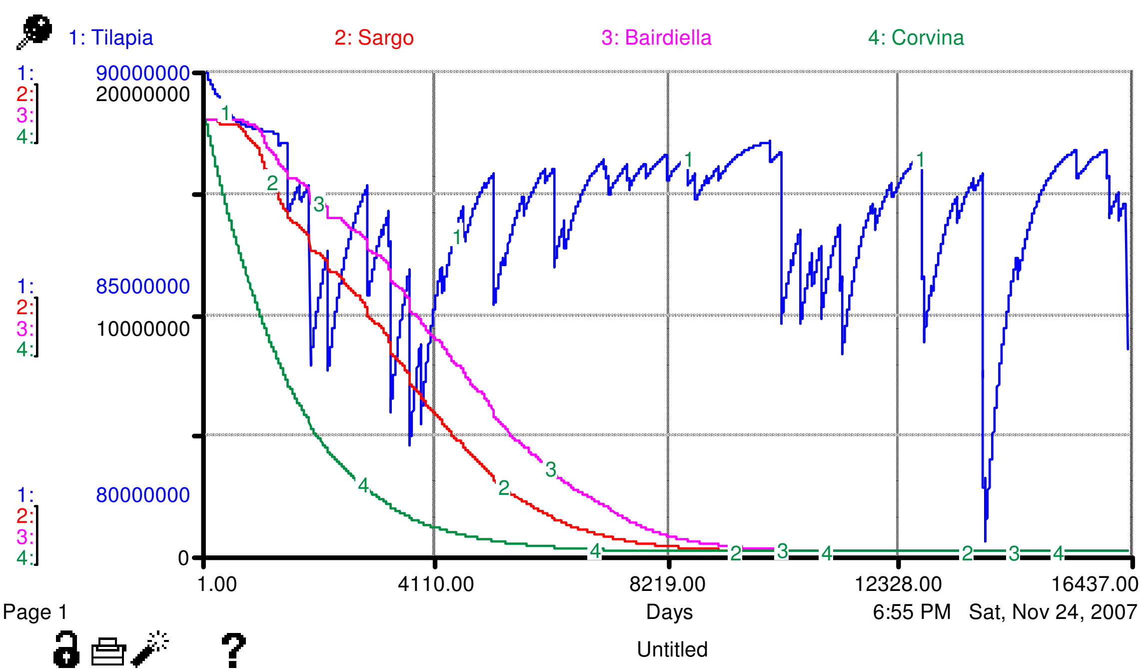

Fig. 20 - Baseline 1 (strategy 1): Salton Sea fish species’ population comparison (1980 - 2024).

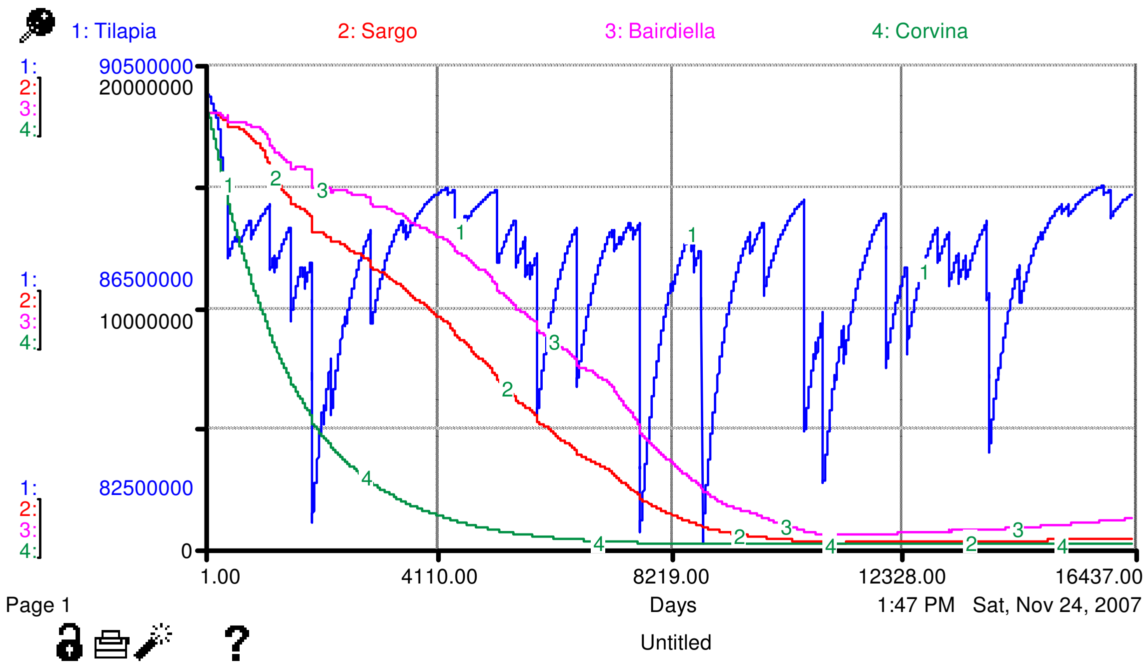

Fig. 21 - Salton Sea impoundment design 1 (strategy 1): north impoundment fish species' population comparison (1980 - 2024).

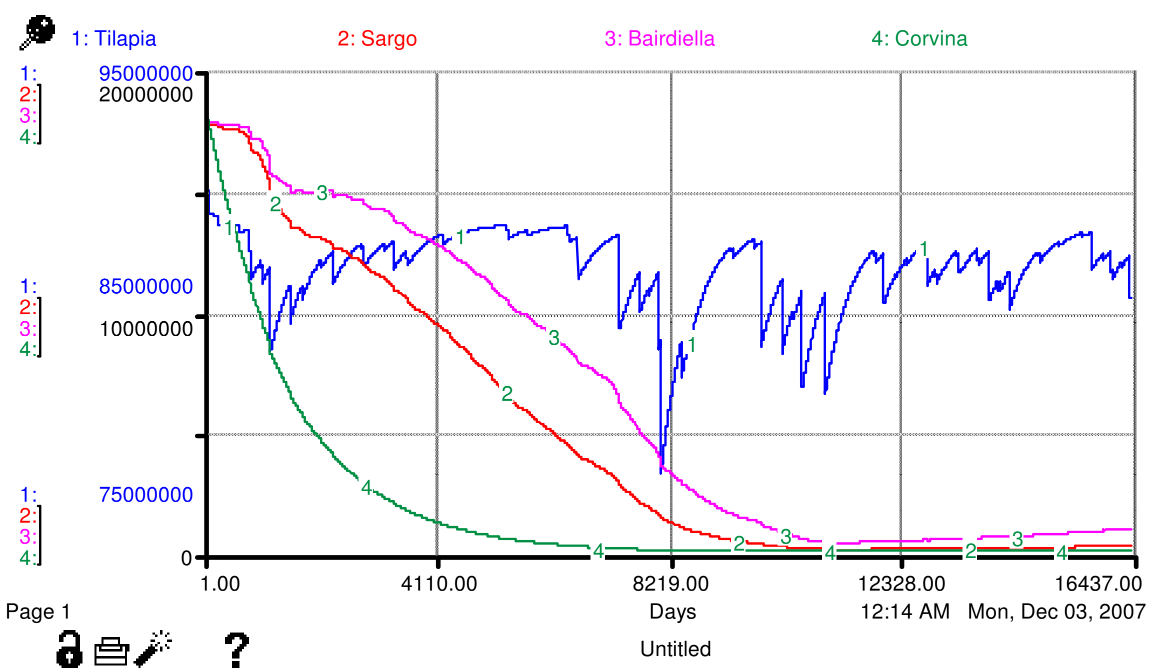

Fig. 22 - Salton Sea impoundment design 2 (strategy 1): north impoundment fish species' population comparison (1980 - 2024).

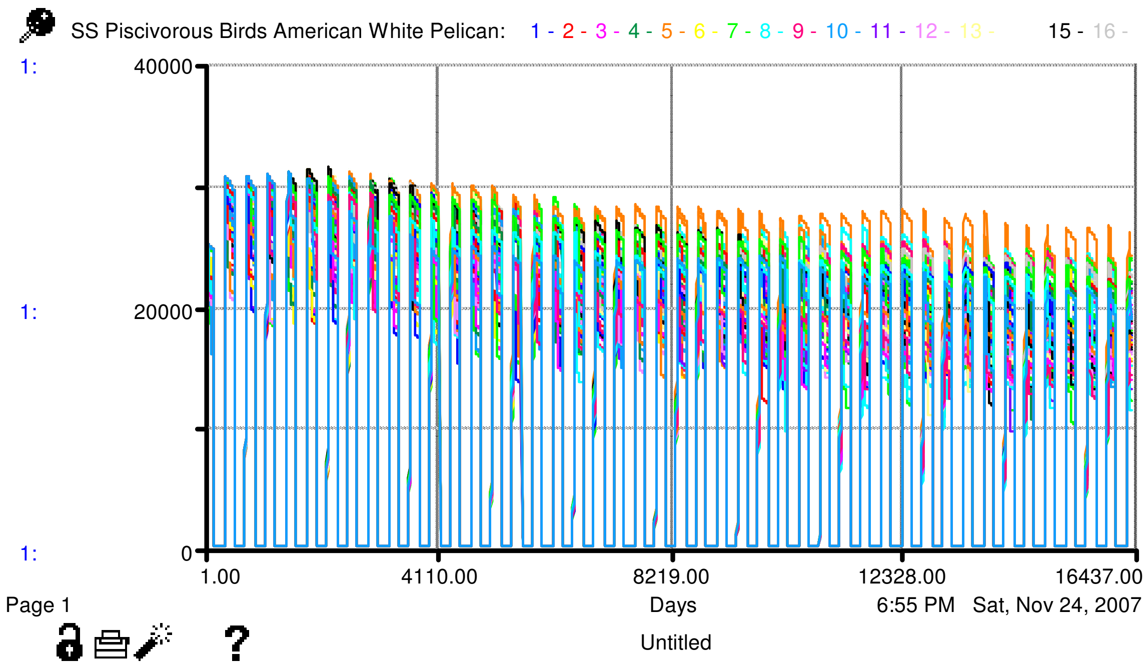

Fig. 23 - Baseline 1 (strategy 1): Salton Sea AWP population (1980 - 2024).

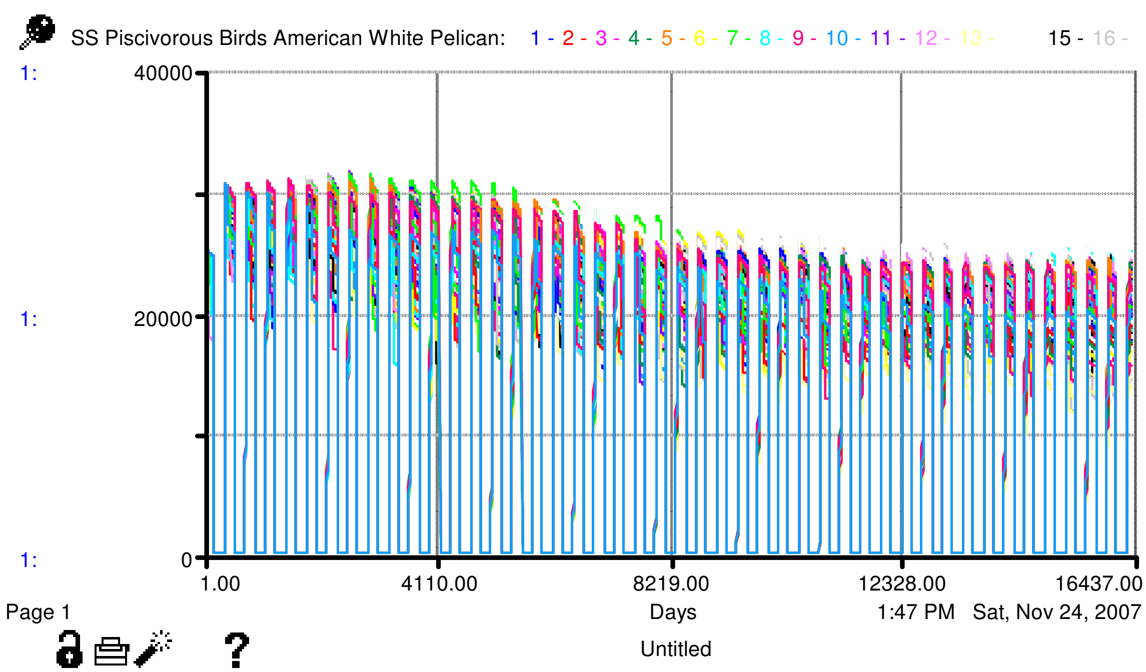

Fig. 24 - Salton Sea impoundment design 1 (strategy 1): AWP population (1980 - 2024).

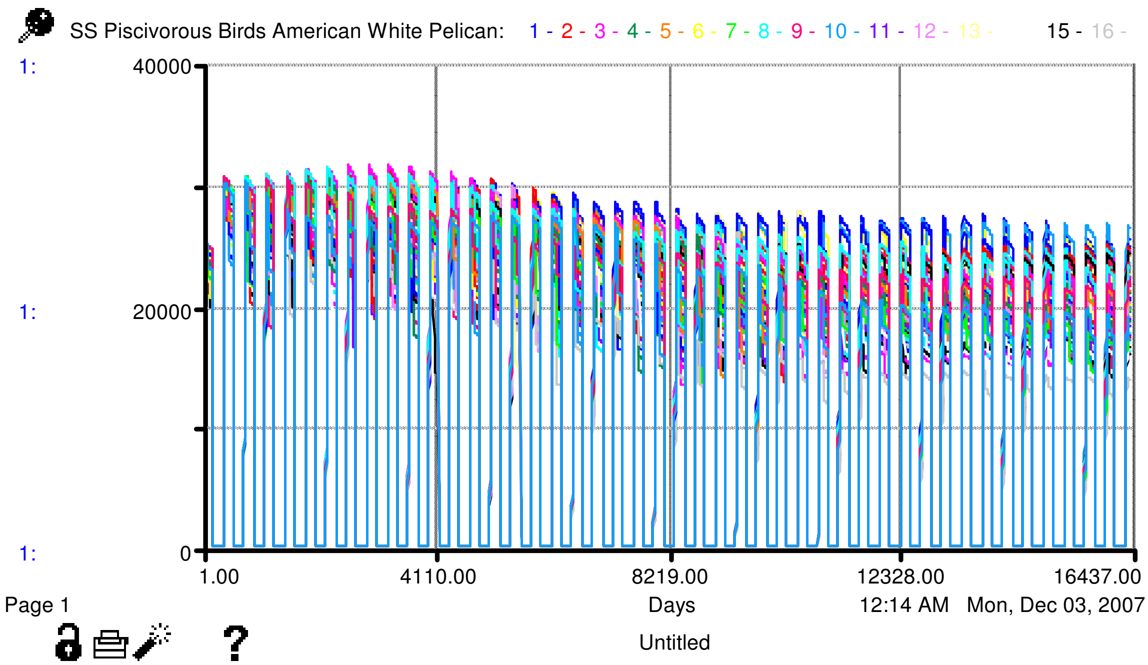

Fig. 25 - Salton Sea impoundment design 2 (strategy 1): AWP population (1980 - 2024).

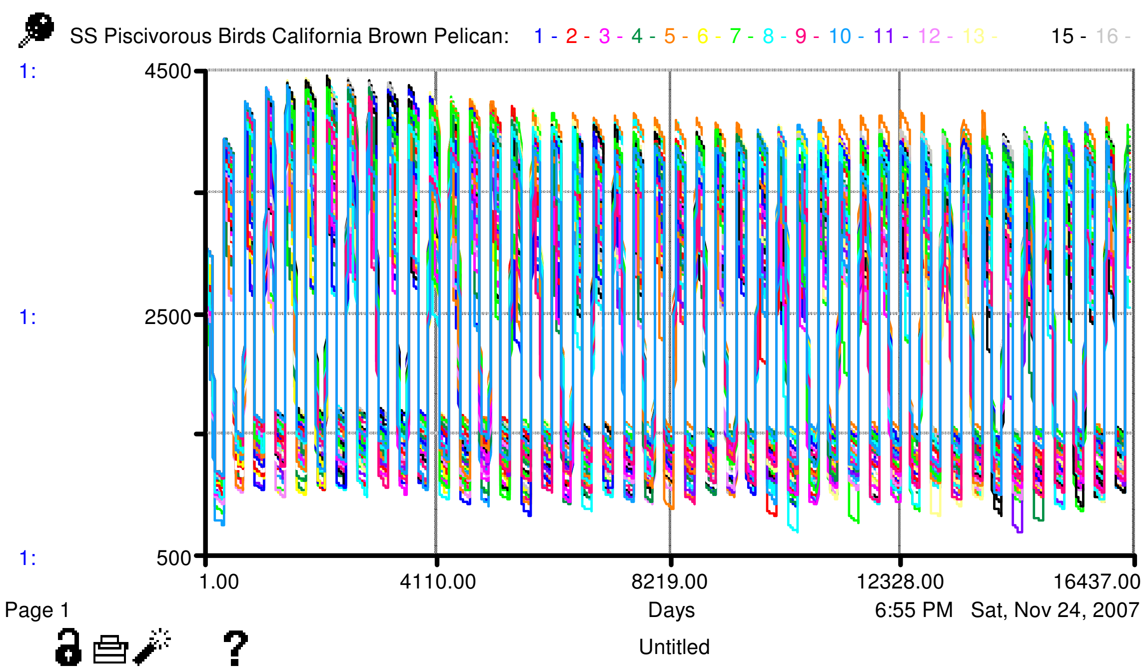

Fig. 26 - Baseline 1 (strategy 1): Salton Sea CBP population (1980 - 2024).

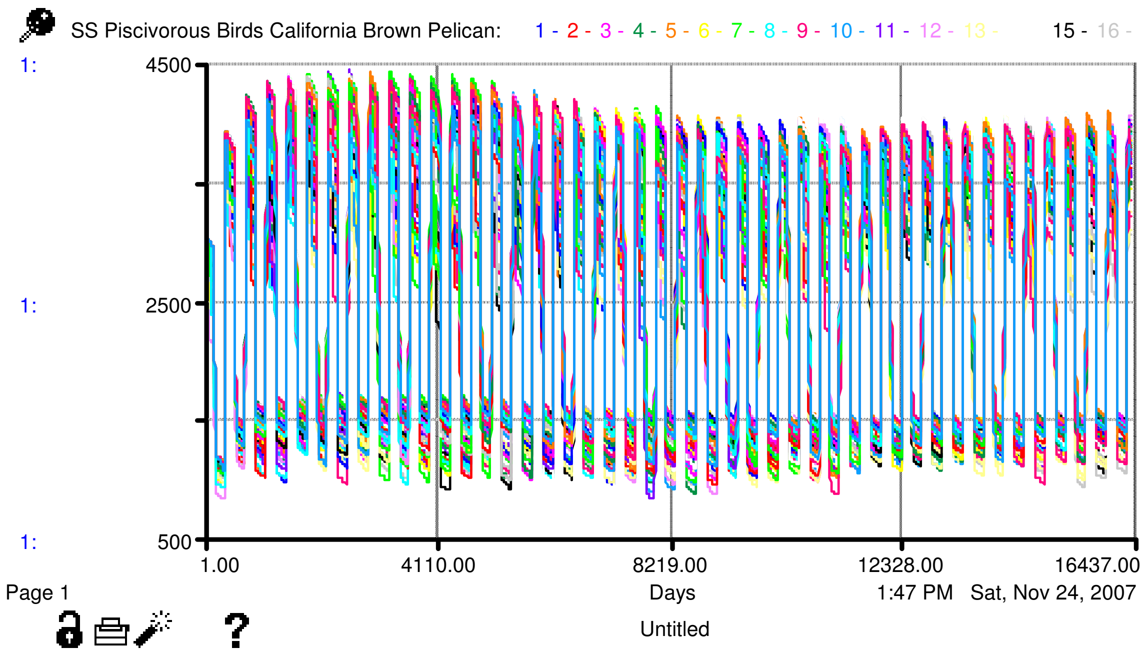

Fig. 27 - Salton Sea impoundment design 1 (strategy 1): CBP population (1980 - 2024)

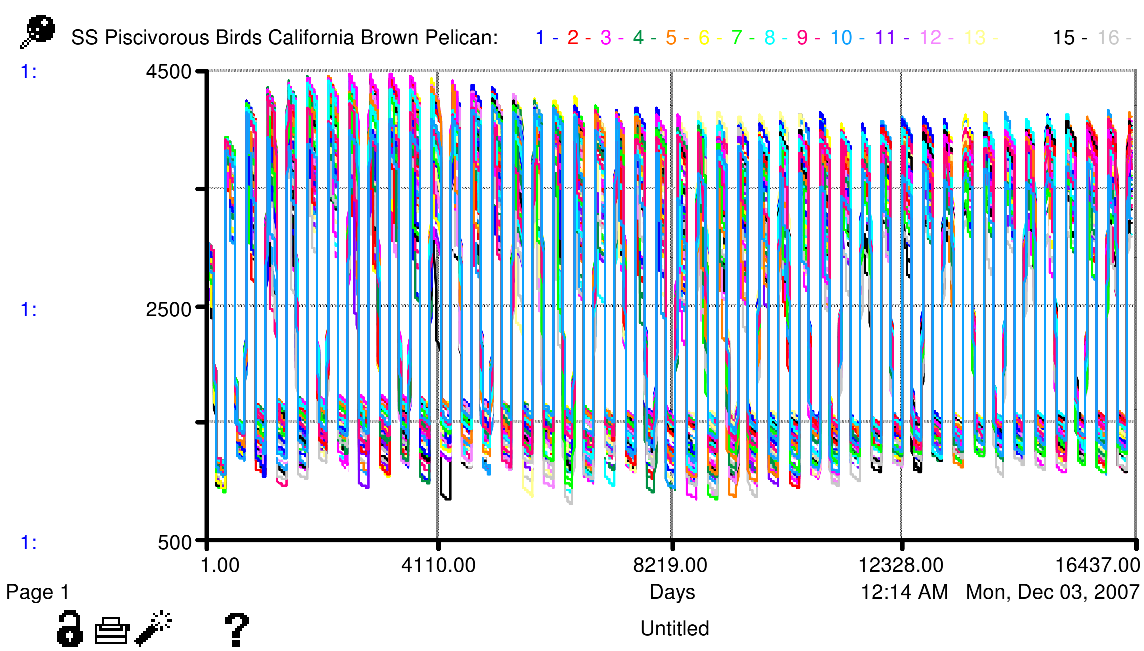

Fig. 28 - Salton Sea impoundment design 2 (strategy 1): CBP population (1980 - 2024).

constructing two more power plants using the same water consumption requirements as the existing power plants. The ANOVA results showed statistically significant ($P<0.05$) differences in elevation and salinity between scenarios 1 and 2. The frequency and strength of algal blooms and the number of fish killed were not significantly different ($P>0.05$) (Tables B.111 & B.112 in Appendix B). There was a significant decrease ($P<0.05$) in three of the four fish species' populations, specifically Tilapia, Sargo, and Corvina, while the change in Bairdiella populations was not significant (Fig. A.215 in Appendix A). Both the AWP and CBP populations showed a slight increase, but the increase was not significant ($P>0.05$), e.g., Fig. A.216 in Appendix A.

Agricultural Fallowing and Lining of the All American Canal (Policies 3 and 5)

Four future scenarios concerning agricultural fallowing and the lining of the All American Canal (AAC) were examined using the deterministic sea inflow version of the simulation model (strategy 1): (1) no lining of the AAC but with the implementation of an agricultural fallowing and mitigation strategy (Baseline) versus (2) a scenario of lining the AAC but without the implementation of an agricultural fallowing strategy, (3) a scenario of lining the AAC and including the implementation of agricultural fallowing, but without mitigation water being sent to the sea, and (4) a scenario of lining the AAC and including the implementation of agricultural fallowing with mitigation water being sent to the sea. Compared to the baseline scenario, scenarios 2, 3, and 4 had significantly higher elevations ($P<0.05$) and significantly lower salinities ($P<0.05$). ANOVAs demonstrated that the differences between the baseline and scenarios 2, 3, and 4 were statistically significant ($P<0.05$).

Populations of all fish species increased significantly (P<0.05) by the end of the simulations in all scenarios, except for the Bairdiella population in scenario 3 which increased but not significantly (P>0.05) (Tables B.105 through B.110 and Figs. A.217 through A.219 in Appendix A. The numbers of fish killed and sum of the percent of fish killed in a population (variables ‘FishKilled’ and ‘FishKillPercent’) decreased in scenarios 2 and 3 and increased in scenario 4, but none of these changes were significant (P>0.05). Algal fish kills (variables ‘DeathAlgalFishKill’ and ‘DeathAlgalFishKillIndex’ decreased significantly (P<0.05) in scenarios 2, 3, and 4 compared to the baseline scenario (Figs. 29 through 31). Pelican populations did not show a significant change (P>0.05) in any of the scenarios.

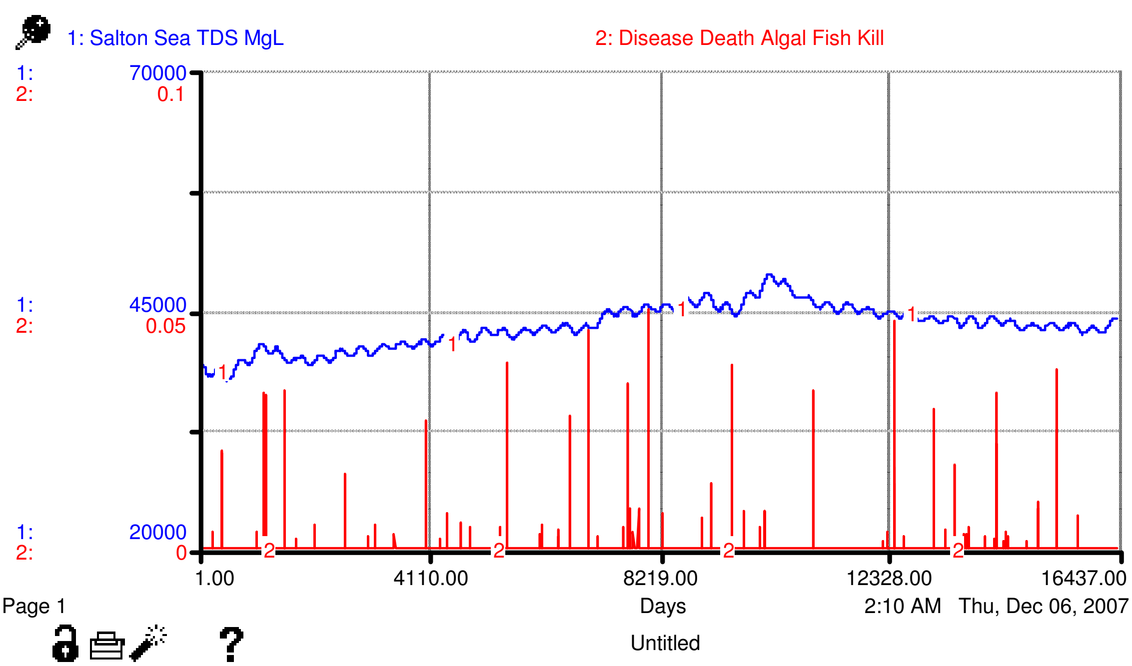

Fig. 29 - AAC lining and agricultural fallowing scenario 2 (policy 3 & 5): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

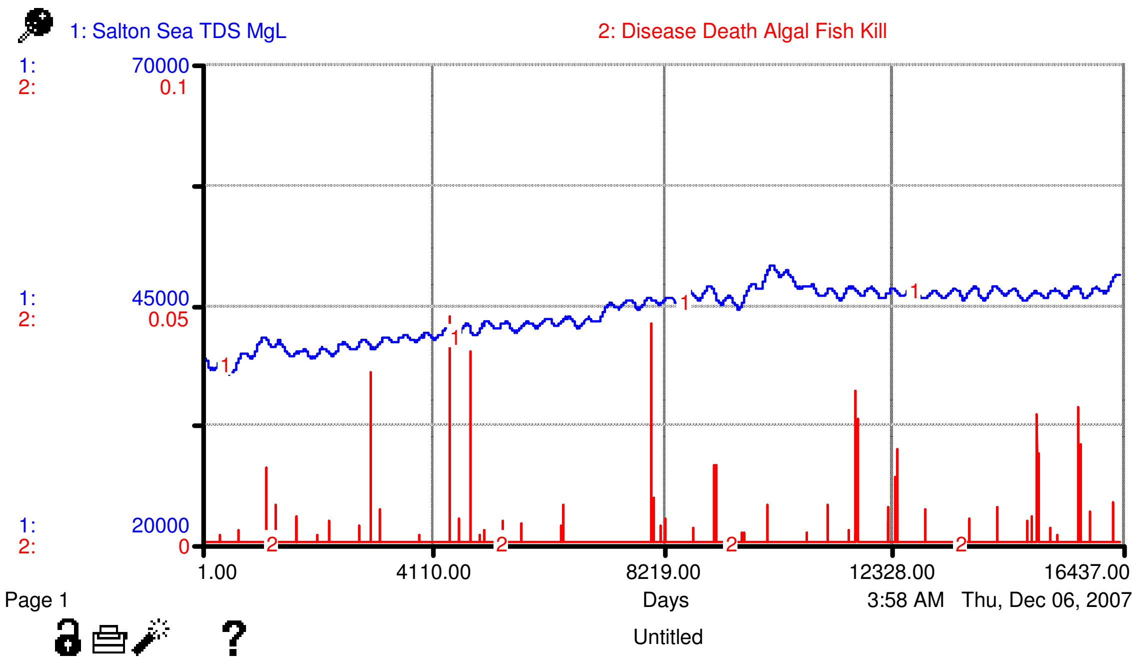

Fig. 30 - AAC lining and agricultural fallowing scenario 3 (policy 3 & 5): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

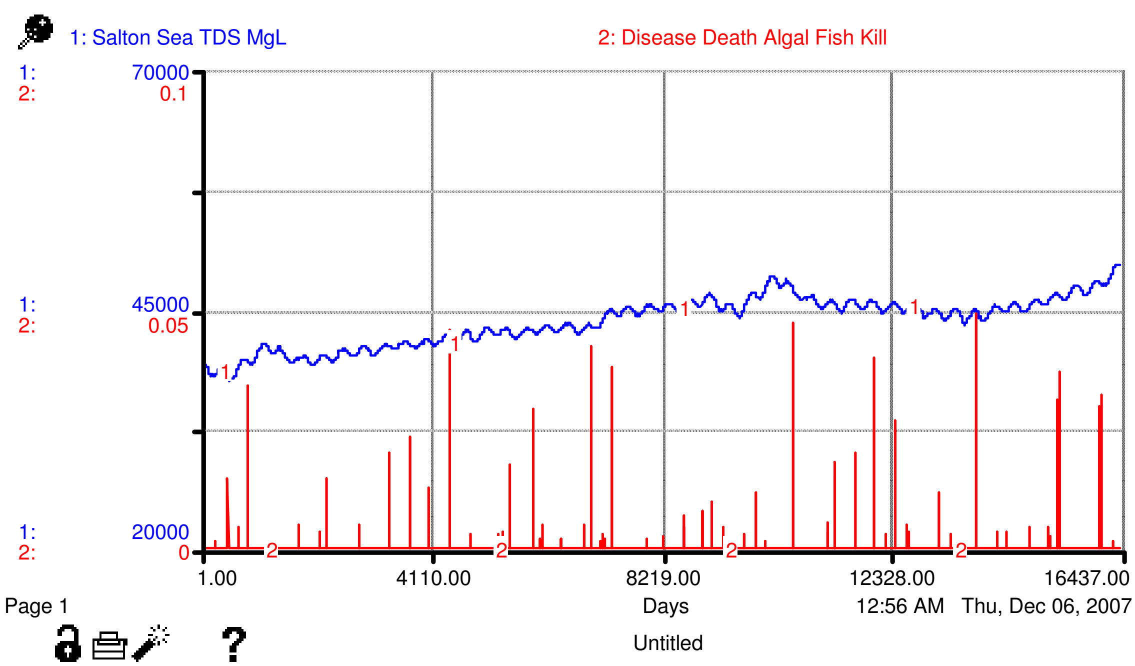

Fig. 31 - AAC lining and agricultural fallowing scenario 4 (policy 3 & 5): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

Brine Extraction (Policy 7)

Two future brine extraction scenarios were examined using strategy 1: (1) no additional construction of evaporation ponds and hence no further brine extraction other than what is currently being done in a pilot project at the Salton Sea versus (2) a scenario of doubling the brine extraction rate due to increasing capacity of evaporation ponds or implementation of an alternative evaporation enhancement method. The ANOVA results showed that there were not statistically significant ($P>0.05$) differences in elevation and salinity between scenarios 1 and 2. As a result, the frequency and strength of algal blooms and the number of fish killed were not significantly different ($P>0.05$) (Tables B.113 & B.114 in Appendix B). The differences in end simulation populations for the fish and bird species, respective variables, were not significantly different from baseline.

Discussion and Conclusions

For ecological reasons, 60,000 mg/L has been identified as a critical peak salinity value (USBR, 2003). If salinity exceeds 60,000 mg/L, the assumption is that fish would not survive and the fishery would need to be re-established once the salinity returned to lower levels. For some inflow conditions, some alternatives have salinity peaks greater than 60,000 mg/L (USBR, 2003).

The Salton Sea model uses similar salinity thresholds, however; the thresholds are relaxed so that natality rates are not 0 (albeit <5%) after thresholds are reached. The assumption is that the freshwater inflow areas of the New, Alamo, and White Water

Rivers, and estuarine areas formed therein, still serve as fish spawning grounds. Since some of the fish can reproduce several times annually, i.e., Tilapia, and produce thousands of larvae per spawn, recruitment may still take place above salinity thresholds in the Salton Sea itself. Beveridge and McAndrew (2000) point out that the spatial structure of Tilapia populations can have important implications for management and may need to be considered explicitly in certain situations. Further, Riedel et al. (2003) lists four fish habitats that could be classified as essential for Salton Sea fish: the freshwater areas of the New and Alamo Rivers, the brackish water or estuarine areas of the New and Alamo Rivers, the shoreline or near shore zones in the sea, and the open or pelagic areas. It is likely then that fish species, notably Tilapia, would not decline to the point of extirpation in the sea, unless conditions deteriorated in the estuarine and river delta areas also. However, the model does not address the sea water quality in such detailed spatial resolution, and therefore cannot be expected to replicate this spatial heterogeneity.

The simulation results produced instances when certain fish species, excluding Tilapia, became functionally extirpated in the Salton Sea. In reality, the likelihood of Tilapia (the most tolerant of these fish species) completely disappearing by the year 2024 seems unlikely given baseline conditions, assuming that breeding stock survive in the estuaries and act as a source for population recruitment. The Tilapia population by the year 2024 does seem too high at 85.8 million (St.Dev. = 1.7×10^6). Conversely, populations of the other species are projected to be functionally extirpated before 2024, e.g. Sargo (10.8, St. Dev. = 1.5), Bairdiella (210.7, St. Dev. = 26.2), and Corvina (7.5, St. Dev. = 1.1). By, 2017 populations of Sargo (<1,000), Bairdiella (<3,000), and Corvina (<400) are still present which may not be realistic based on Cohen and Hyun (2006). Cohen and Hyun (2006) state that within 12 to 15 years, under no action alternatives, fish will disappear from the sea as well as most of the fish-eating birds. Although the sea will continue to be an invertebrate prey base but by 2077 brine shrimp, brine fly, and other invertebrate numbers will be reduced, as well as the birds that feed upon them (Cohen and Hyun, 2006).

The results of the sensitivity analyses indicated that the relationships in the model held without any unexplainable and unrealistic results. Based on the simulation results and under the assumptions utilized in the parameterization, one should accept the hypothesis that the proposed action will not significantly impact selected populations of fish and avian species for the following water management scenario: (d) extracting brine from the sea did not produce significantly different results from baseline for populations of fish and bird species. One should reject the hypothesis that the proposed action will not significantly impact selected populations of fish and avian species for the following water management scenario: (a) lining the AAC with concrete and fallowing farmland in the IV resulted in populations of all fish species increasing significantly ($P<0.05$); (b) operating additional power plants in Mexicali resulted in Tilapia, Sargo, and Corvina populations decreasing significantly ($P<0.05$); (c) additional wetlands in the New River Wetlands project resulted in Sargo and Corvina populations increasing significantly ($P<0.05$); and (e) dividing the sea into north and south impoundments resulted in a significant increase ($P<0.05$) in both fish and bird species populations for both impoundment scenarios 2 and 3.

Although the scenarios of lining the AAC with concrete and fallowing farmland in the IV resulted in significantly increased populations of all fish species by 2024, the salinities were still high, i.e. 43,878 ppm, 47,833 ppm, and 49,681 ppm for scenarios 2, 3, and 4, respectively. In comparison, the impoundment scenarios resulted in much lower salinities for the north sea with 7,262 ppm and 15,083 ppm for scenarios 2 and 3, respectively, and significantly increased populations of both fish and Pelican species. Given the likelihood of future reduced sea inflows, increased annual and seasonal average temperatures (Salton Sea Ecosystem Restoration Program, 2006) and associated increased evaporation; the AAC canal lining and fallowing farmland scenarios will likely not serve to maintain fish and pelican populations for long and may even be detrimental as algal blooms and large die-off events continue to occur over time (policies 3 & 5). Should action be taken to stabilize the sea and reduce salinity, the impoundment scenarios demonstrated the most success in significantly increasing both fish and pelican populations over the long term.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The goal of this research was to develop an integrated systems simulation model that could be useful in addressing some of the complex environmental and natural resource management problems in the LCRB, and more specifically the Salton Sea. The Salton Sea model contains good representations of important hydraulic components in the LCRB and the Salton Sea Basin. The model is developed to illustrate how a system dynamics approach can assist decision-makers in evaluating how the Salton Sea might be affected by alternative policies proposed for water management in the LCRB. The result is a systems simulation model to investigate the complexities, interconnections, and feedbacks that underlie the Salton Sea ecosystem and the implications of water transfers on ecosystem/human health and local/bi-national economies.

The results herein can provide important contributions to the understanding of the interface between natural and human systems in the Lower Colorado River Basin; provide general lessons about the resilience of policies in water-scarce environments; and generate useful guidance for the environmental, social, and economic consequences of water policies in the Lower Colorado River Basin, specifically involving the Salton Sea. By modeling the potential impacts of the policies and practices that currently are or may be implemented in the Lower Colorado River Basin, it is possible to identify mitigation strategies as well as utilize the model to simulate their effectiveness.

Problems/Issues Encountered

The research presented herein consisted of incorporating several pieces of the complex dynamics involving the LCRB, while including issues of a bi-national context. In order to reasonably construct the model to represent hydrology, hydraulics, land-use, demographics, and potential decision-making policies, many details in terms of historic data were, and may continue to be, incorporated. Sometimes the acquisition of historic data was difficult due to availability or manageability given the available format or inherent subjectivity. As a result, many assumptions had to be made, but at the same time the option of changing a particular assumption in a "user friendly way" was incorporated into the model whenever feasible.

Preferred Salton Sea Management Option

The model herein simulated the effects of changes in water volume, TDS, and P on the Salton Sea, as a result of the six proposed fore-mentioned water management policies. Based on the analyses, and defining the preferred state of the Salton Sea similar to Tetra Tech, Inc. (2000), the policy with impoundment scenarios (policy 2) was the "best" option for restoring the Salton Sea (see attached supplemental PowerPoint file) in terms of "improving and maintaining ecological conditions" as listed in Cohen et al. (1999). The impoundment scenarios would have long term benefits such as those listed by in the Salton Sea Restoration Draft EIS/EIR by Tetra Tech, Inc. (2000) including the following: 1.) maintaining the sea as an agricultural repository, 2) providing a sanctuary for resident and migratory birds and endangered species, 3) restoring recreational uses, 4) maintaining a viable sport fishery, 5) increasing the potential for economic development opportunities at the sea.

Some of the present study's modeling results have already been incorporated into a much larger modeling project (B+20 Project) conducted by the Southwest Center for Environmental Research and Policy SCERP. The B+20 Project was designed to develop a framework for supporting interdisciplinary, bi-national decision-making in the U.S.-Mexico Border Region (Forster, 2002). SCERP was created by the U.S. Congress in October 1990 to initiate a comprehensive analysis of possible solutions to the acute air, water quality, and hazardous waste problems that plague the United States-Mexico border region (Institute for Regional Studies of the Californias, 2002).

The entire modeling process, not just the results of the model itself, has already generated useful guidance for the environmental consequences of potential water policies in the LCRB, and helped the members of the Border+20 project team and local stakeholders/decision-makers better understand how management decisions may affect the future of the Salton Sea and the entire region. It is hoped that the modeling results within can generate further guidance for policy makers in the region, and also provide a useful approach to be used for similar situations in other semi-arid environments.

Ultimately, the fate of the Salton Sea is merely a reflection of society's values. Do we value the sea and all the natural embodiments that rely upon it or are intermingled with it? Do we pay the price to preserve the sea or continue to wait and pay the price of losing it? The cost of doing something now may well be less than the foregone benefits of the future, if no action is taken.

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APPENDIX A

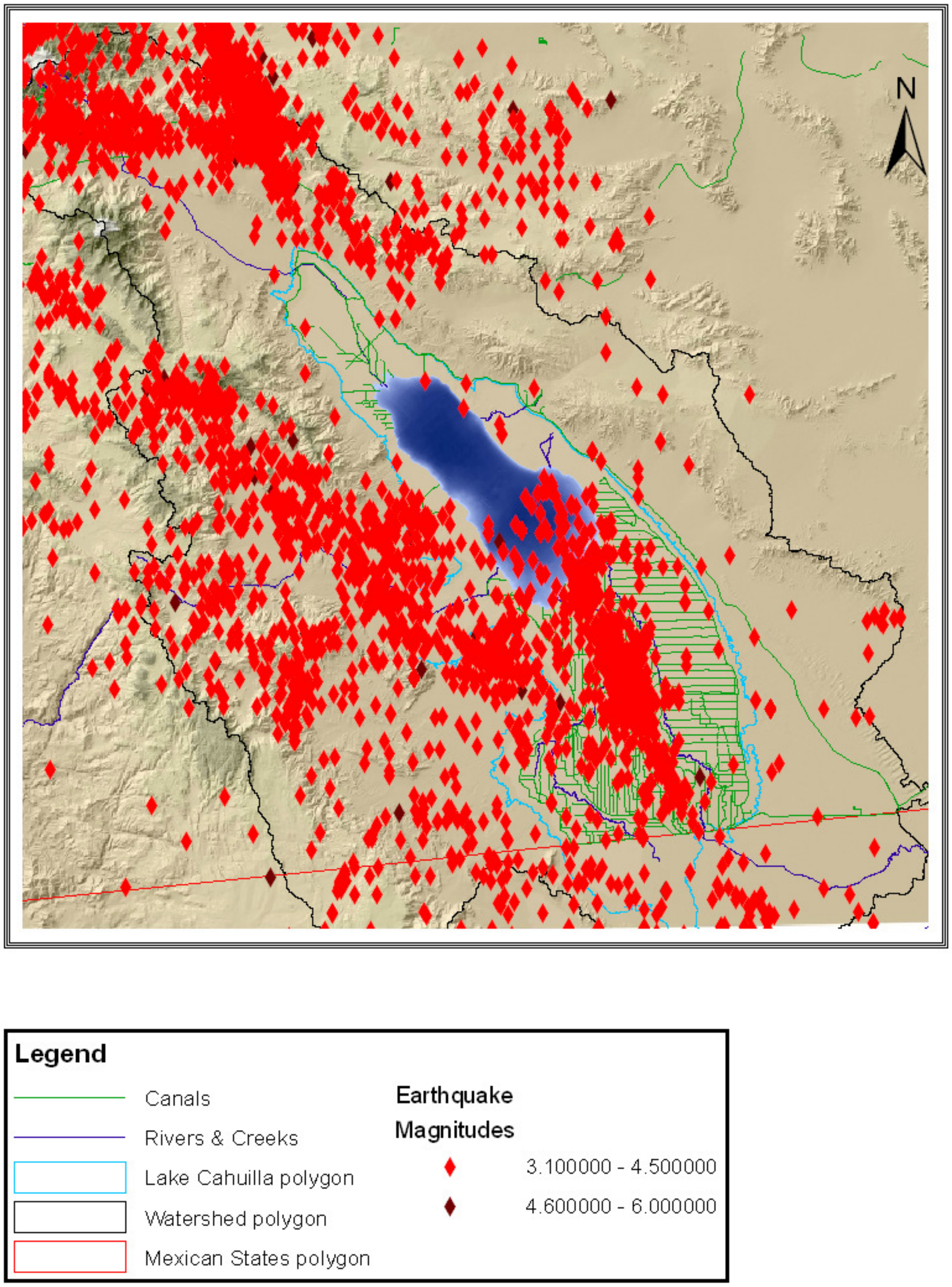


Fig. A.1 - Salton Sea moderate and major earthquake centers (Richter Scale Measurements).

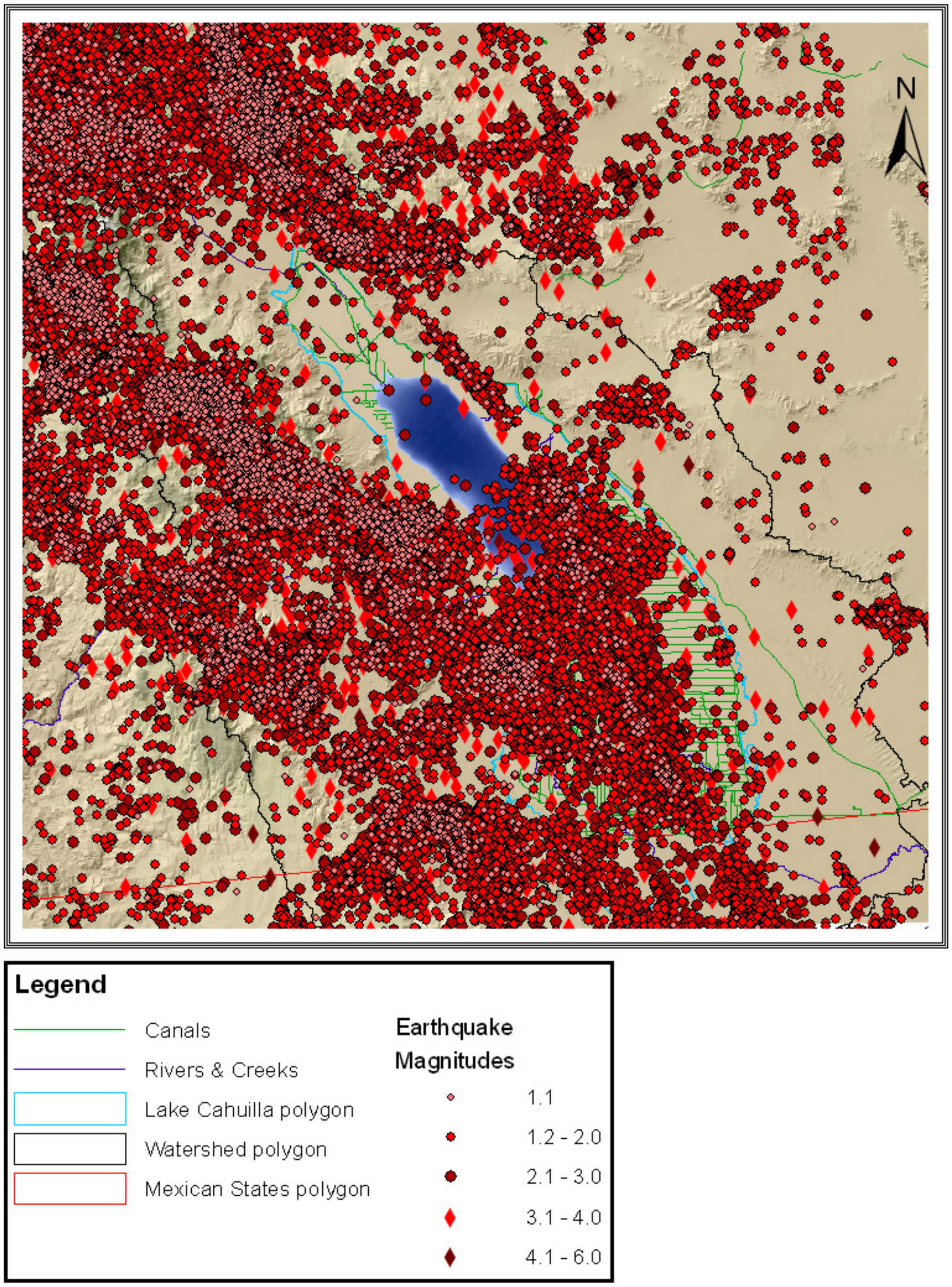


Fig. A.2 - Salton Sea earthquake centers (Richter Scale Measurements).

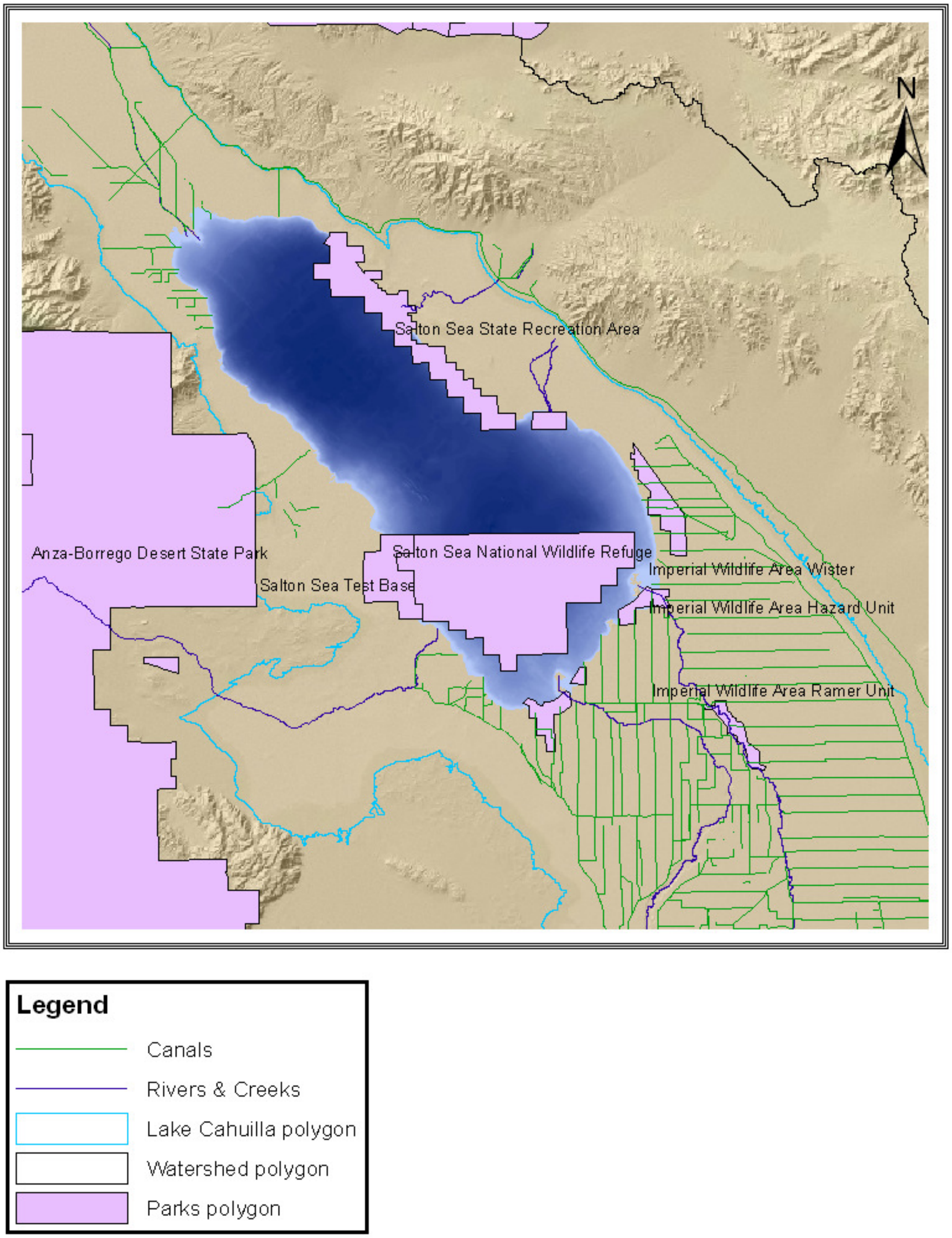


Fig. A.3 - Parks, wildlife areas, and wildlife refuges on or near the Salton Sea.

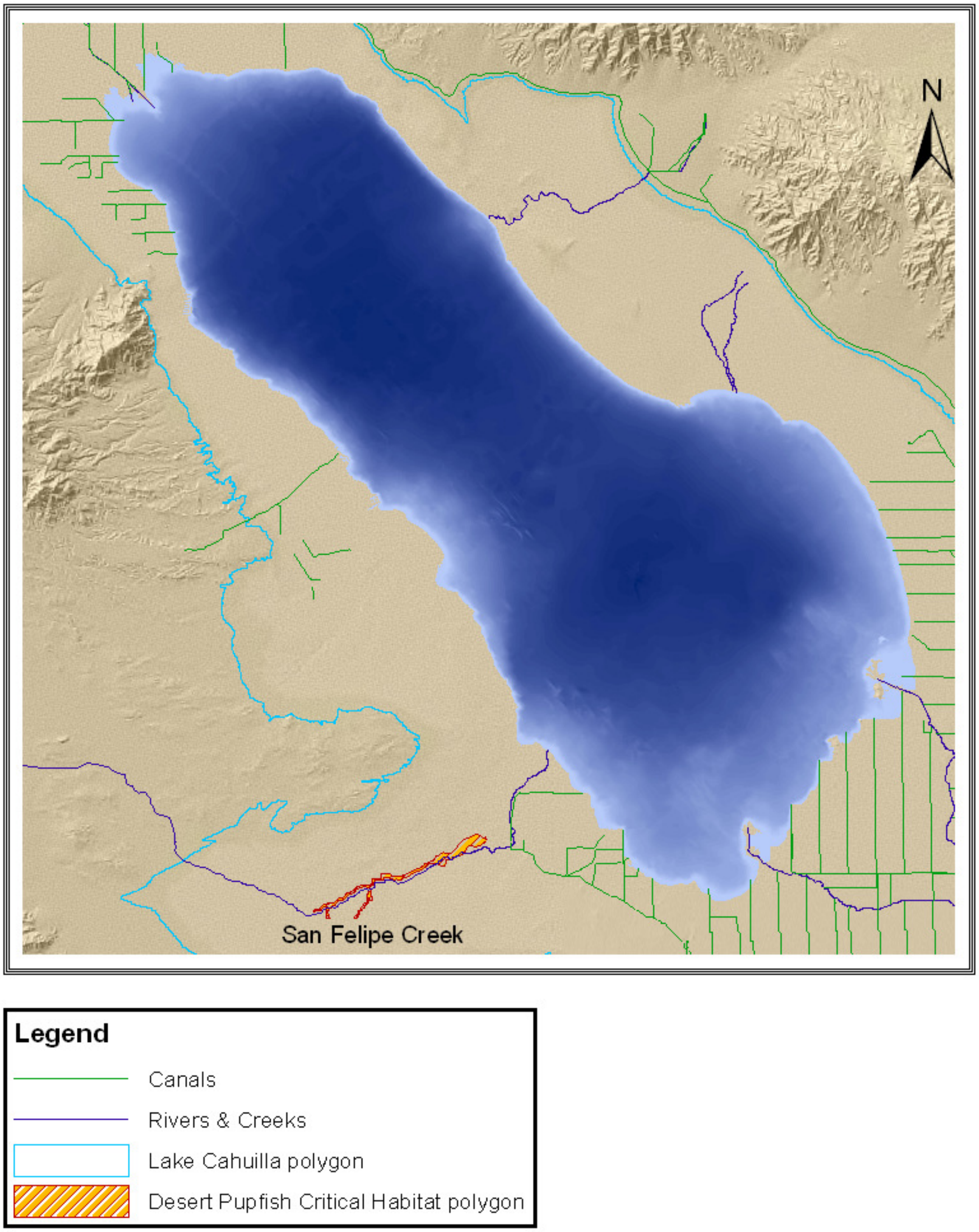


Fig. A.4 - Desert Pupfish critical habitat near the Salton Sea.

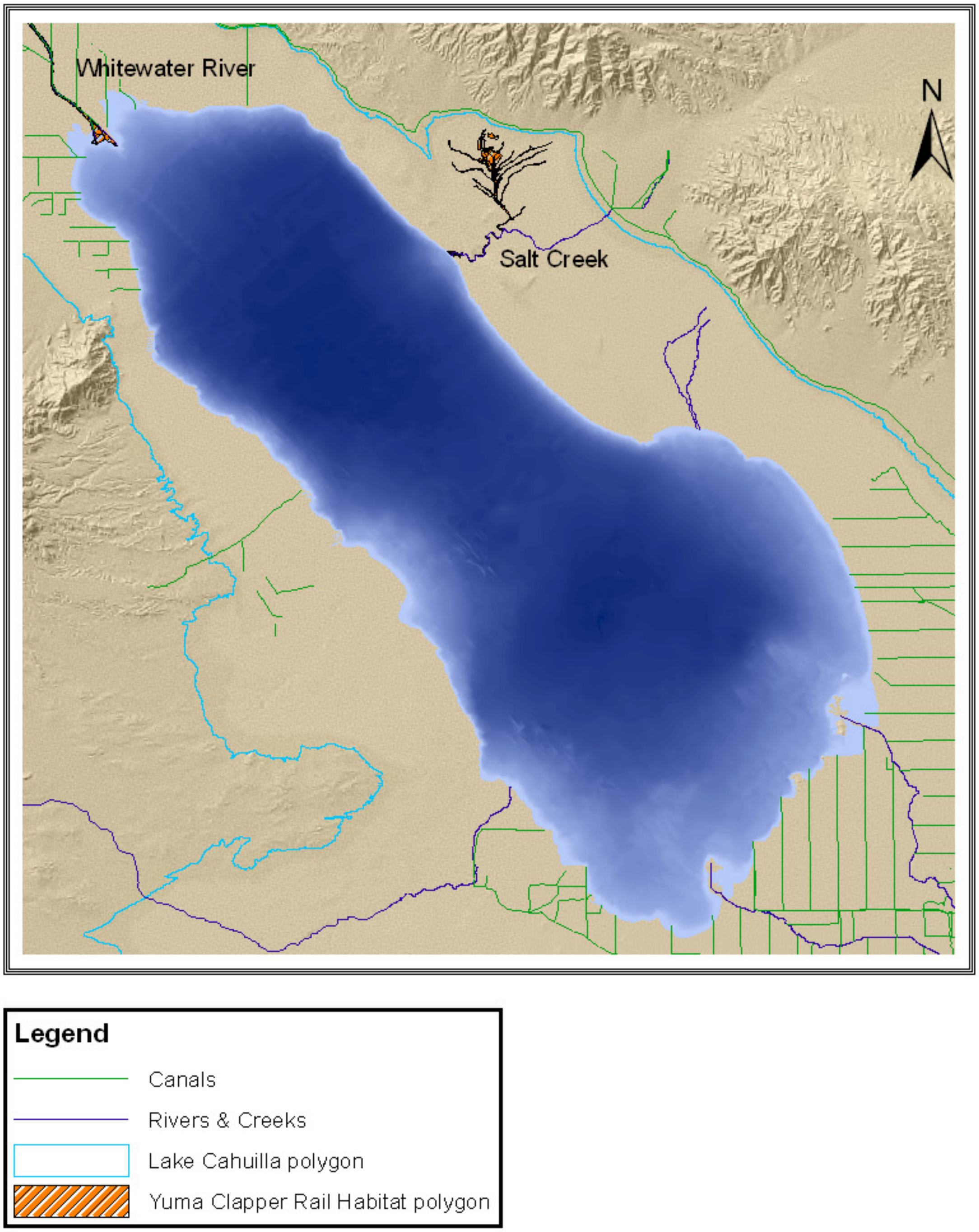


Fig. A.5 - Yuma Clapper Rail critical habitat near the Salton Sea.

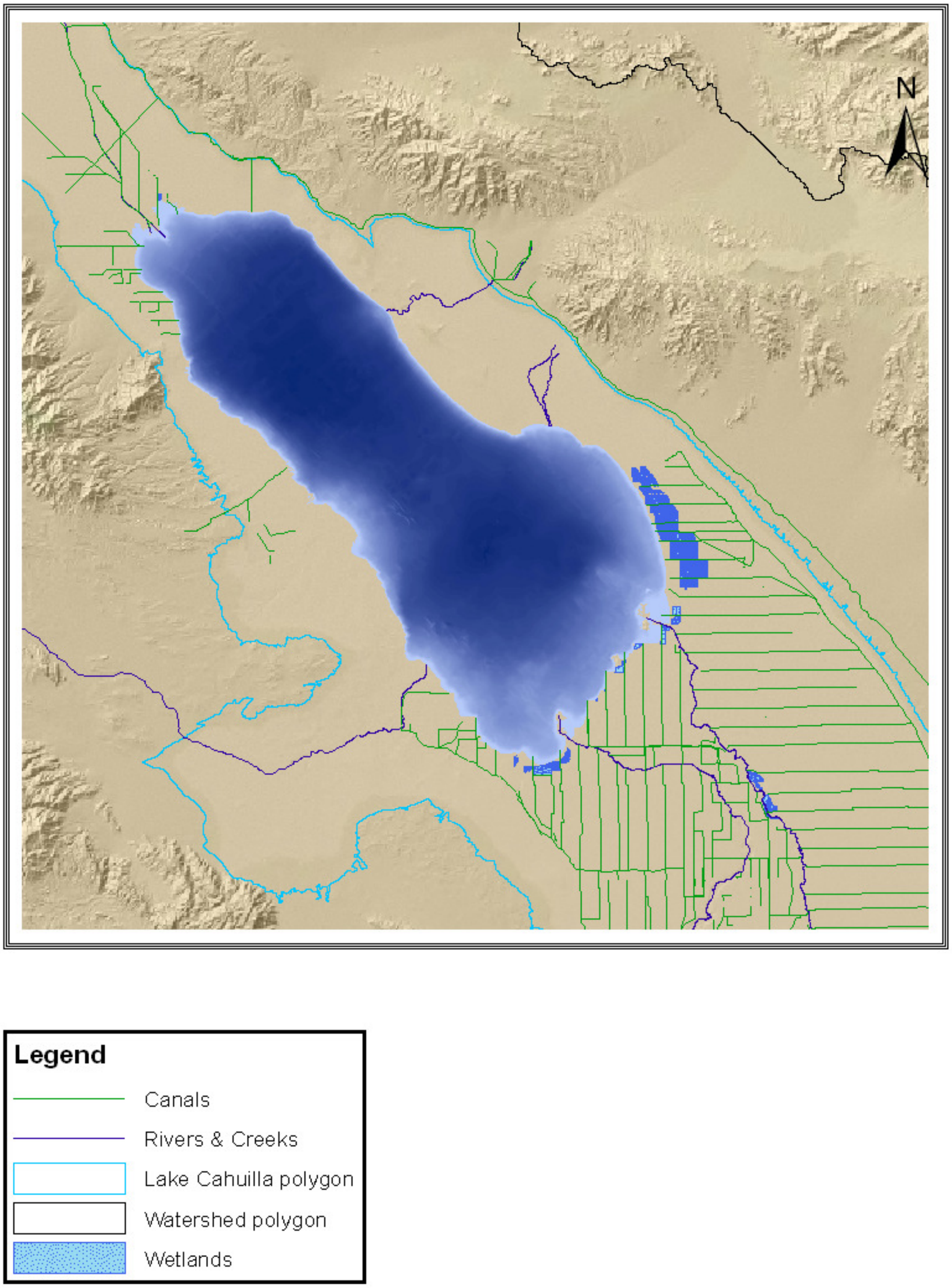


Fig. A.6 - Wetlands near the Salton Sea.

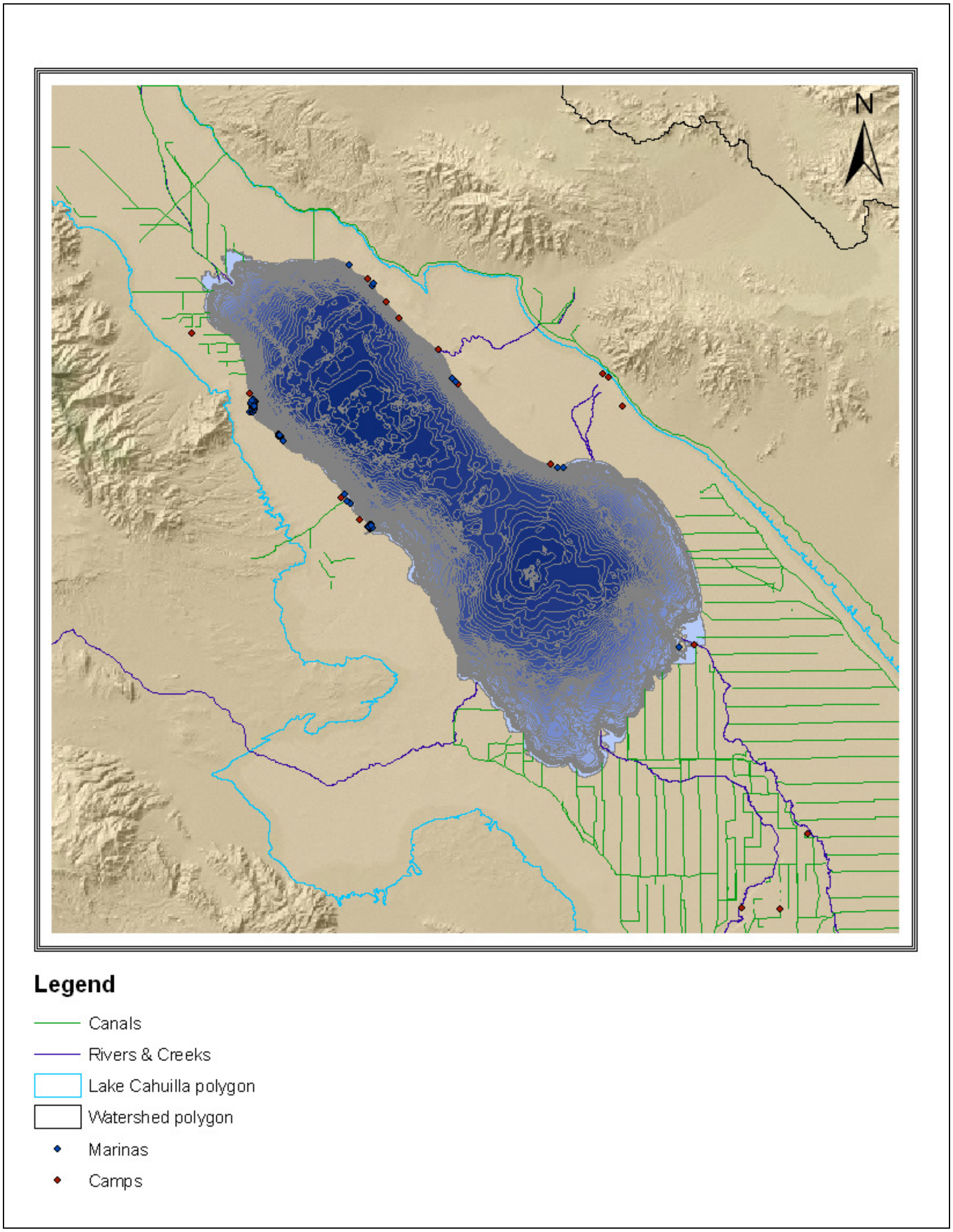


Fig. A.7 - Marinas and camping grounds around the Salton Sea.

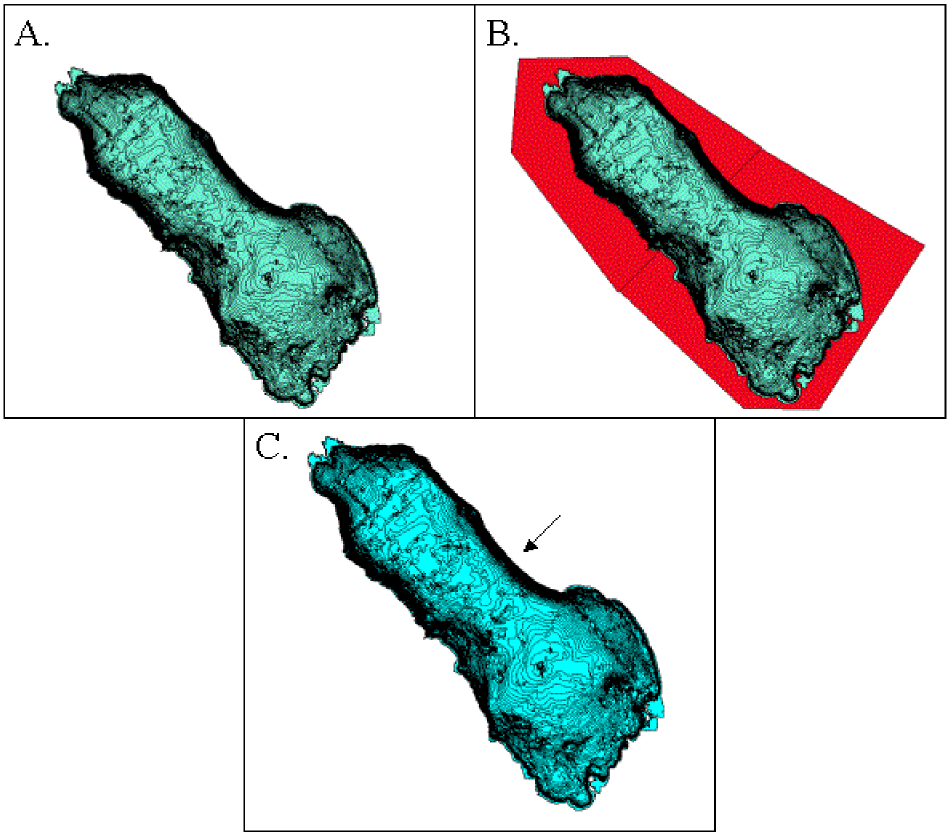


Fig. A.8 - Delineating the Salton Sea polygon area to be separated into two polygons.

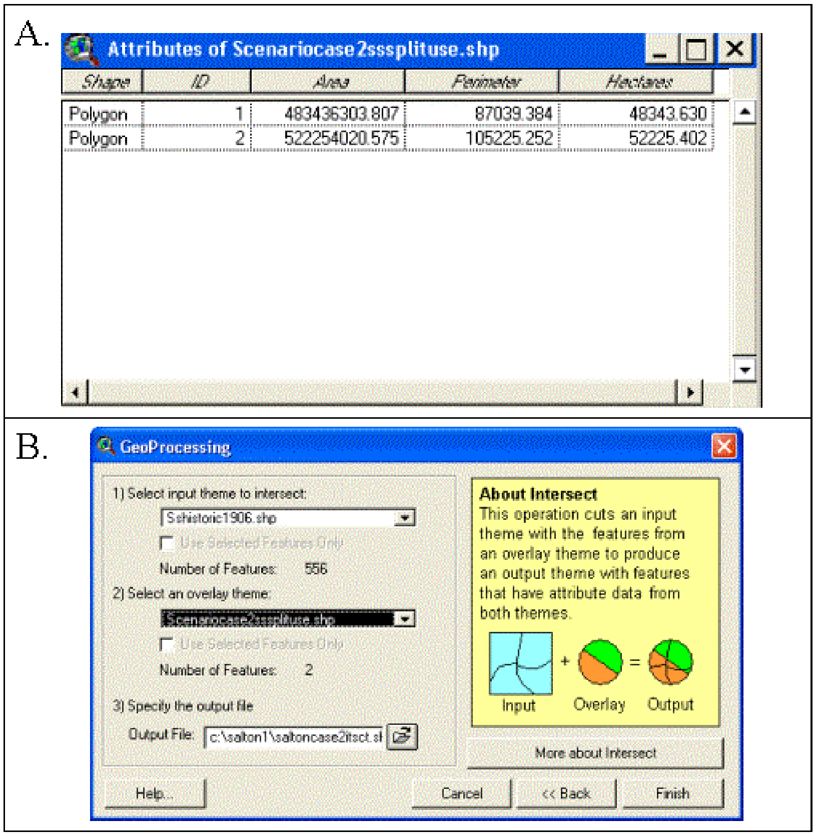


Fig. A.9 - Attribute table showing separate polygons representing the two new impoundments for the Salton Sea (Fig. A.9A) and the GeoProcessing Wizard’s ‘Intersect Two Themes’ window (Fig. A.9B).

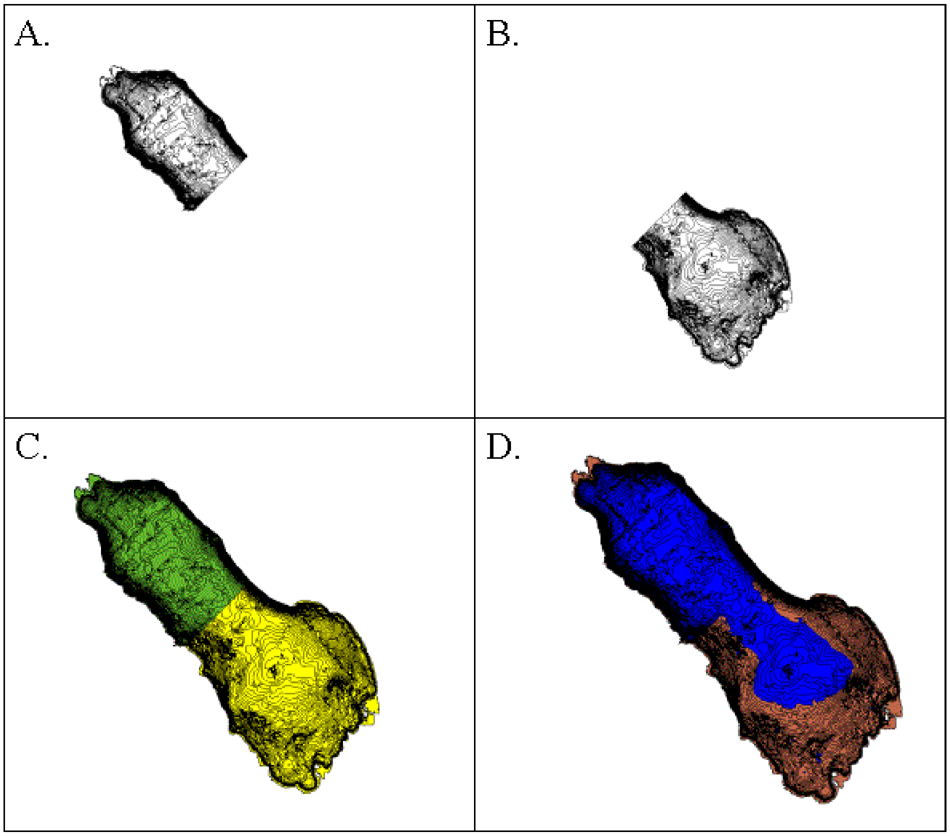


Fig. A.10 - Salton Sea partitioned into north and south impoundments – scenario 2.

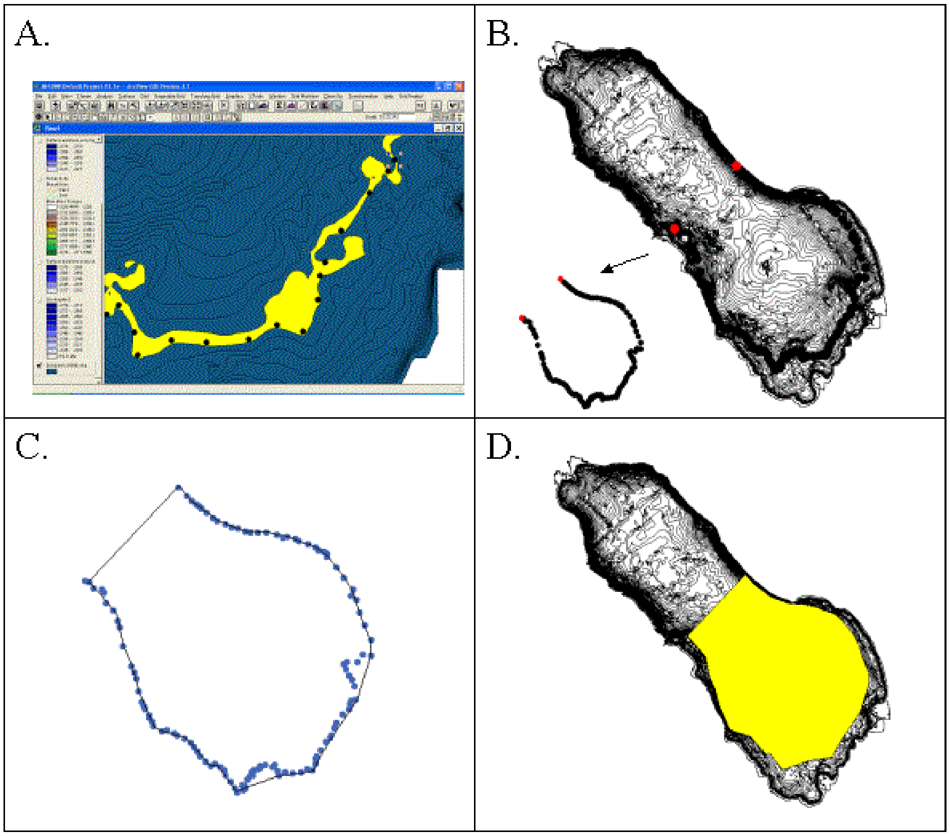


Fig. A.11 - Partitioning the Salton Sea into north and south impoundments – scenario 3.

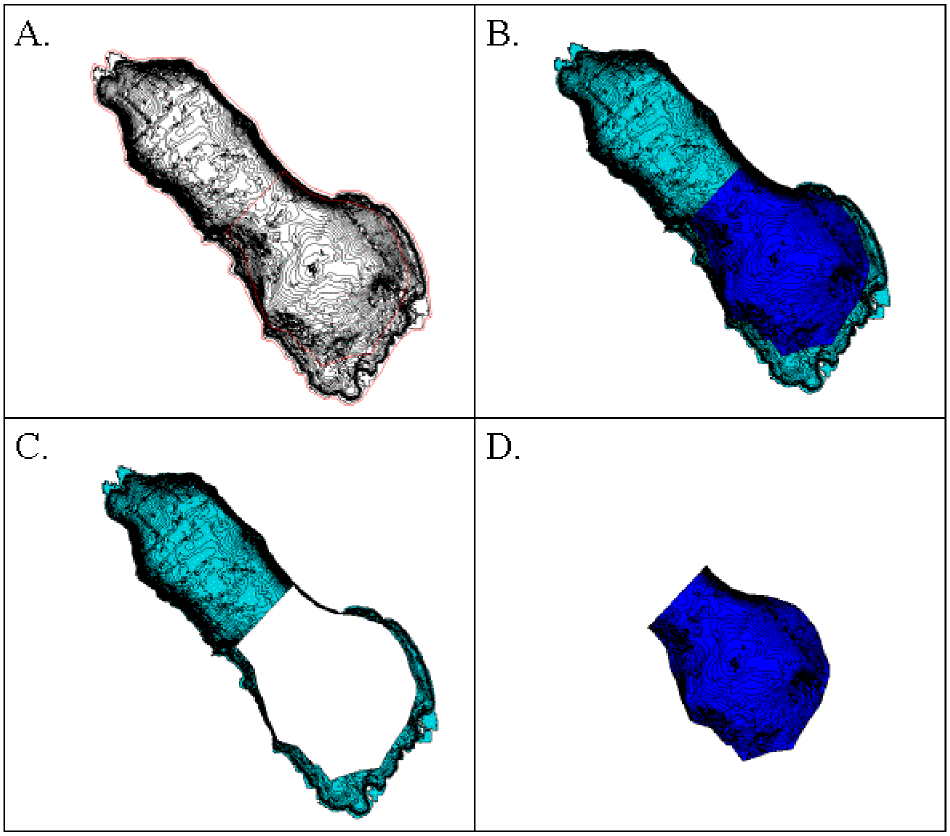


Fig. A.12 - Salton Sea partitioned into north and south impoundments – scenario 3.

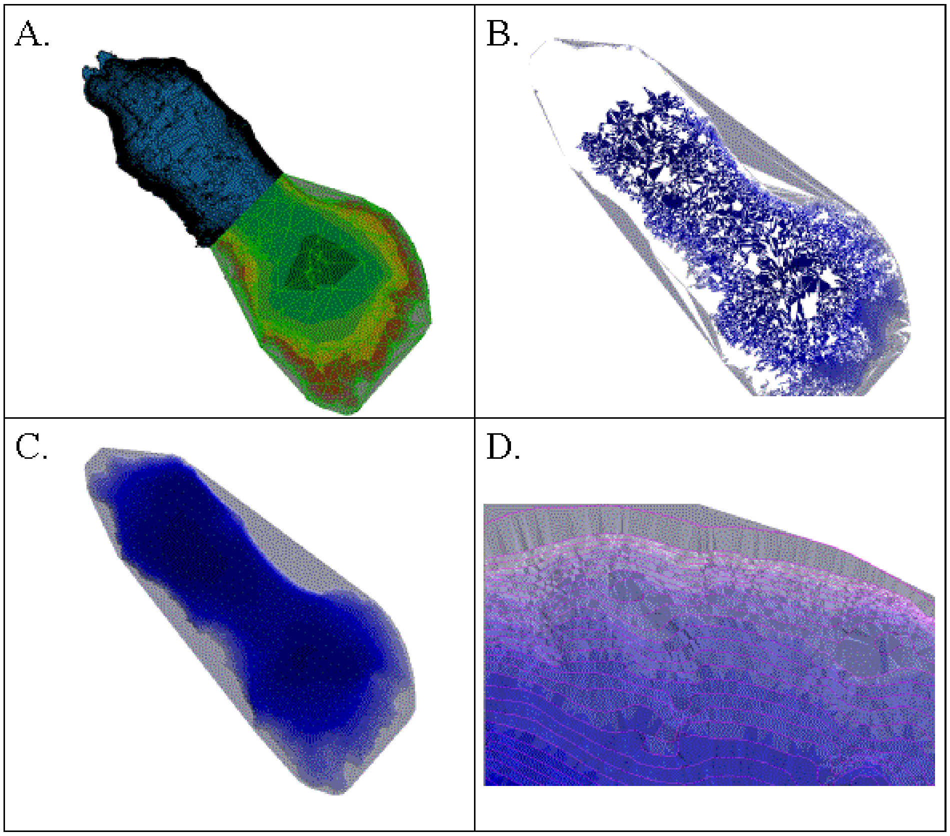


Fig. A.13 - Conversion of Salton Sea shapefile to a TIN file for calculating new volume and surface area.

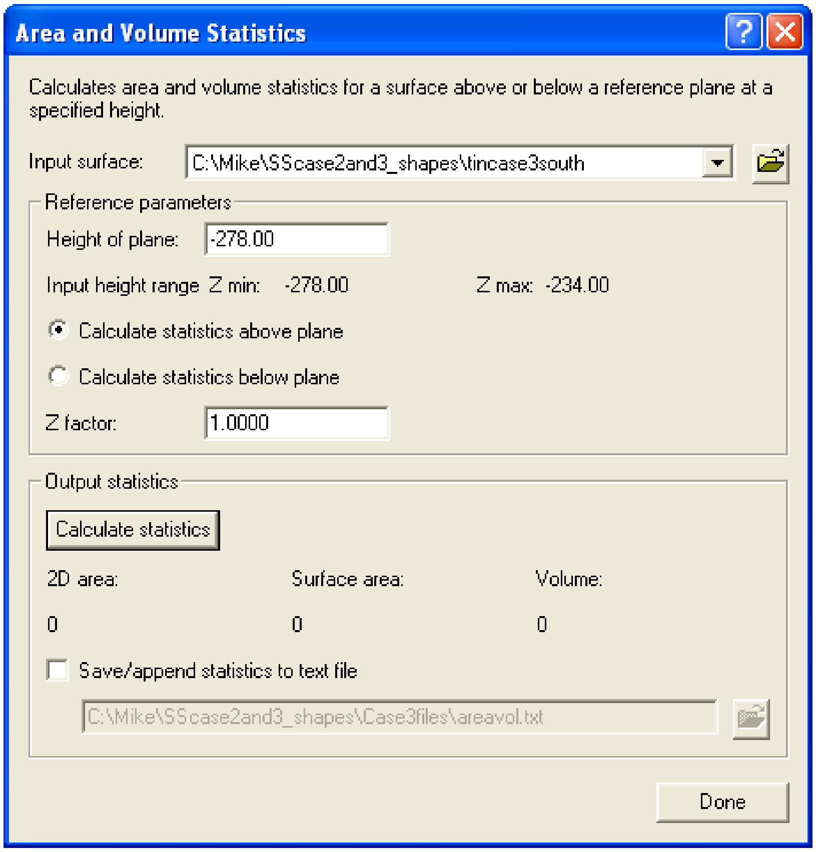


Fig. A.14 - The ArcGIS “Area and Volume Statistics” window.

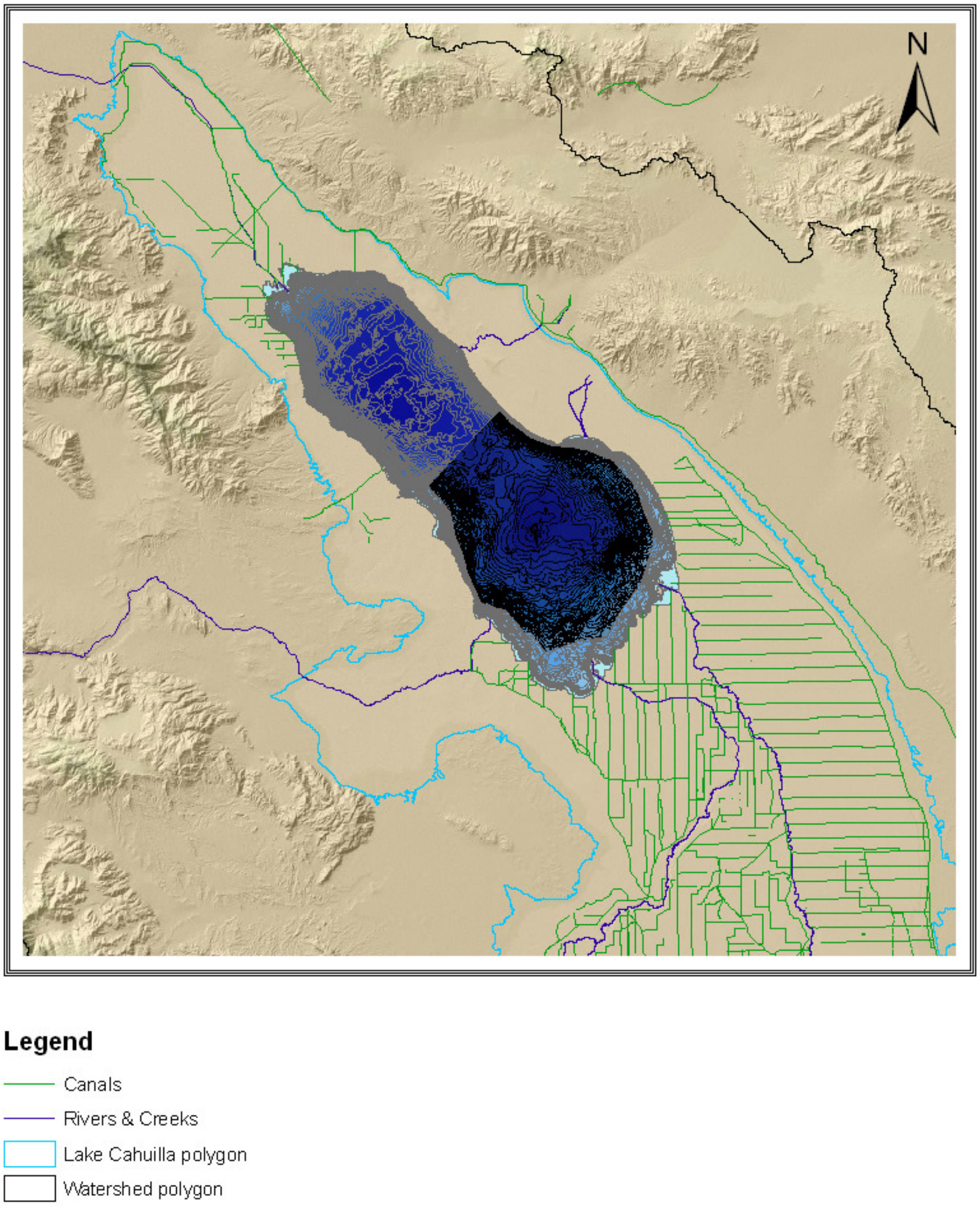


Fig. A.15 - The Salton Sea partitioned into north and south impoundments – scenario 3.

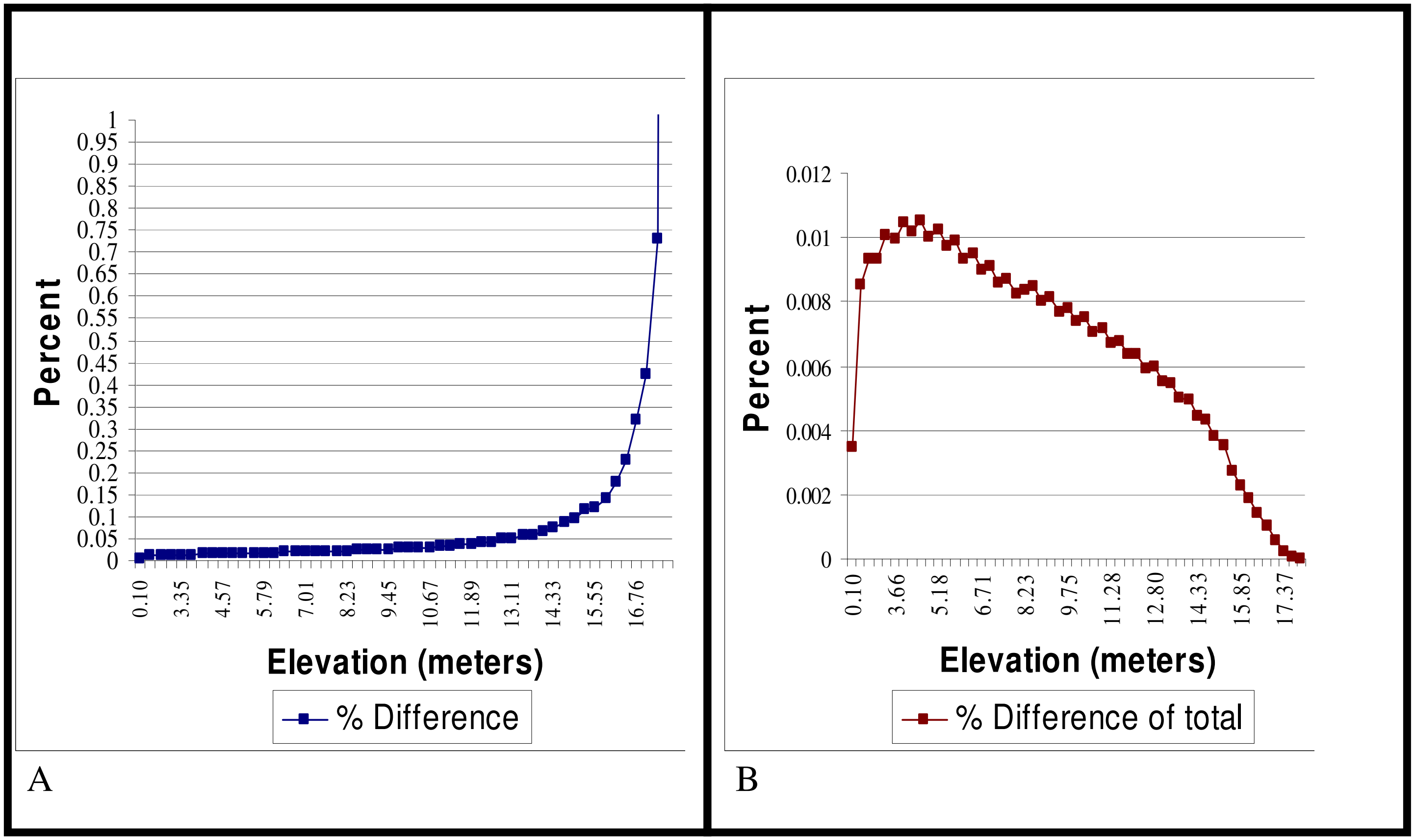


Fig. A.16 - Scenario 2 TIN calculated elevations and volumes versus USBR report calculations.

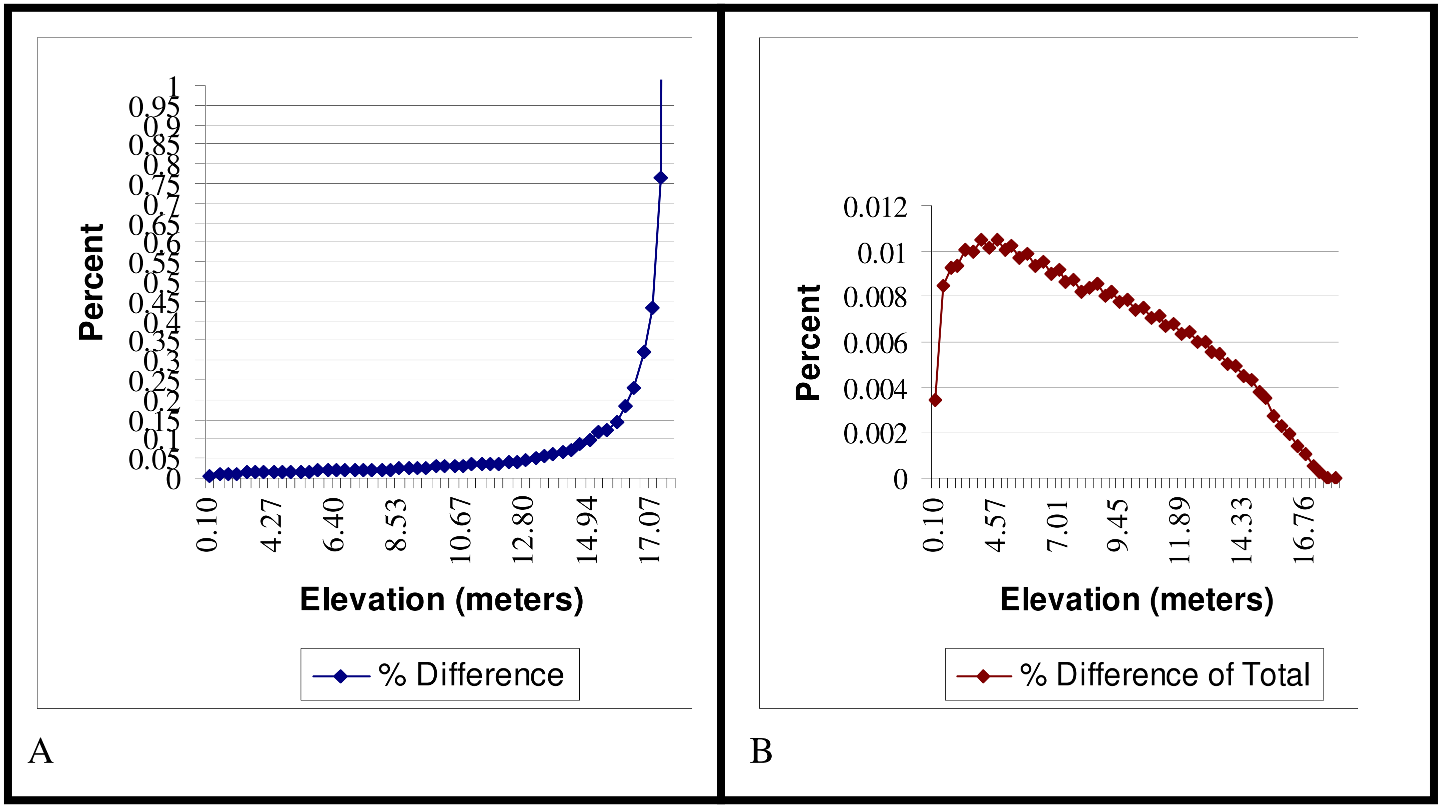


Fig. A.17 - Scenario 3 TIN calculated elevations and volumes versus USBR report calculations.

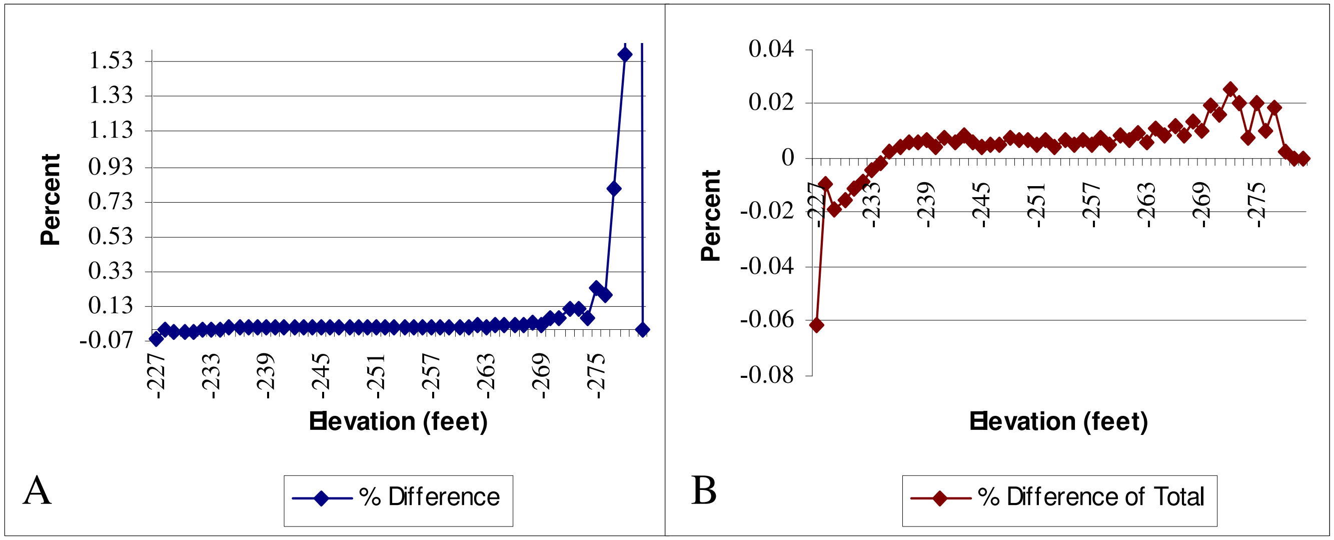


Fig. A.18 - Scenario 2 TIN calculated surface area versus USBR report calculations.

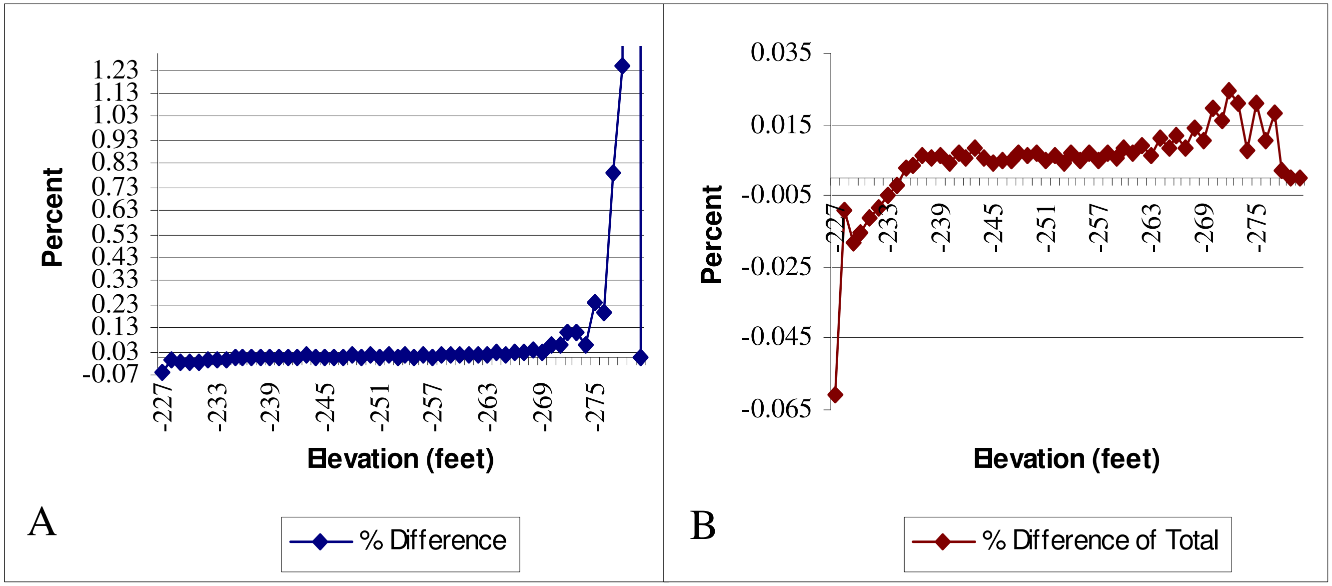


Fig. A.19 - Scenario 3 TIN calculated surface area versus USBR report calculations.

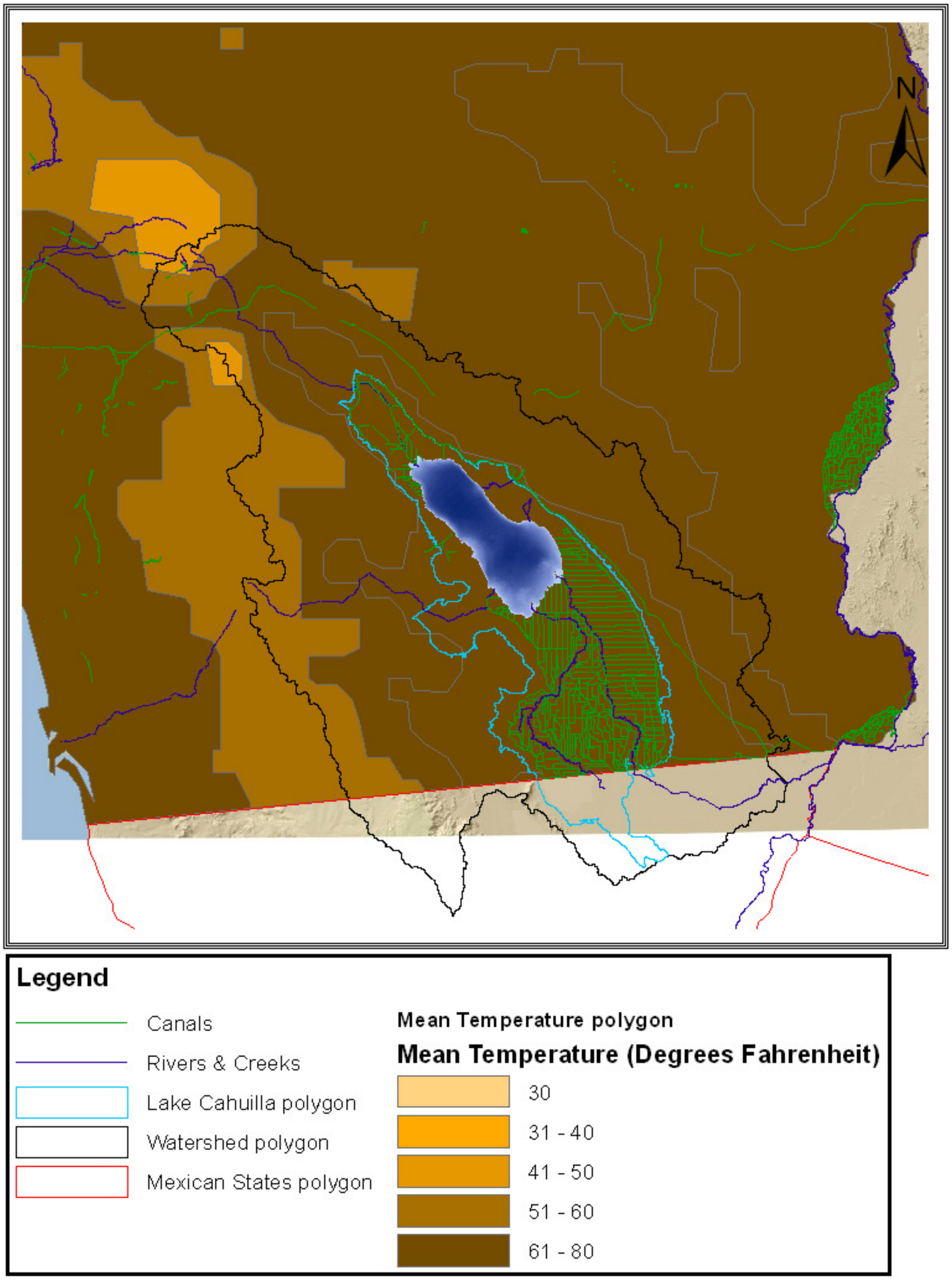


Fig. A.20 - Average annual temperature in and around the Salton Sea Basin.

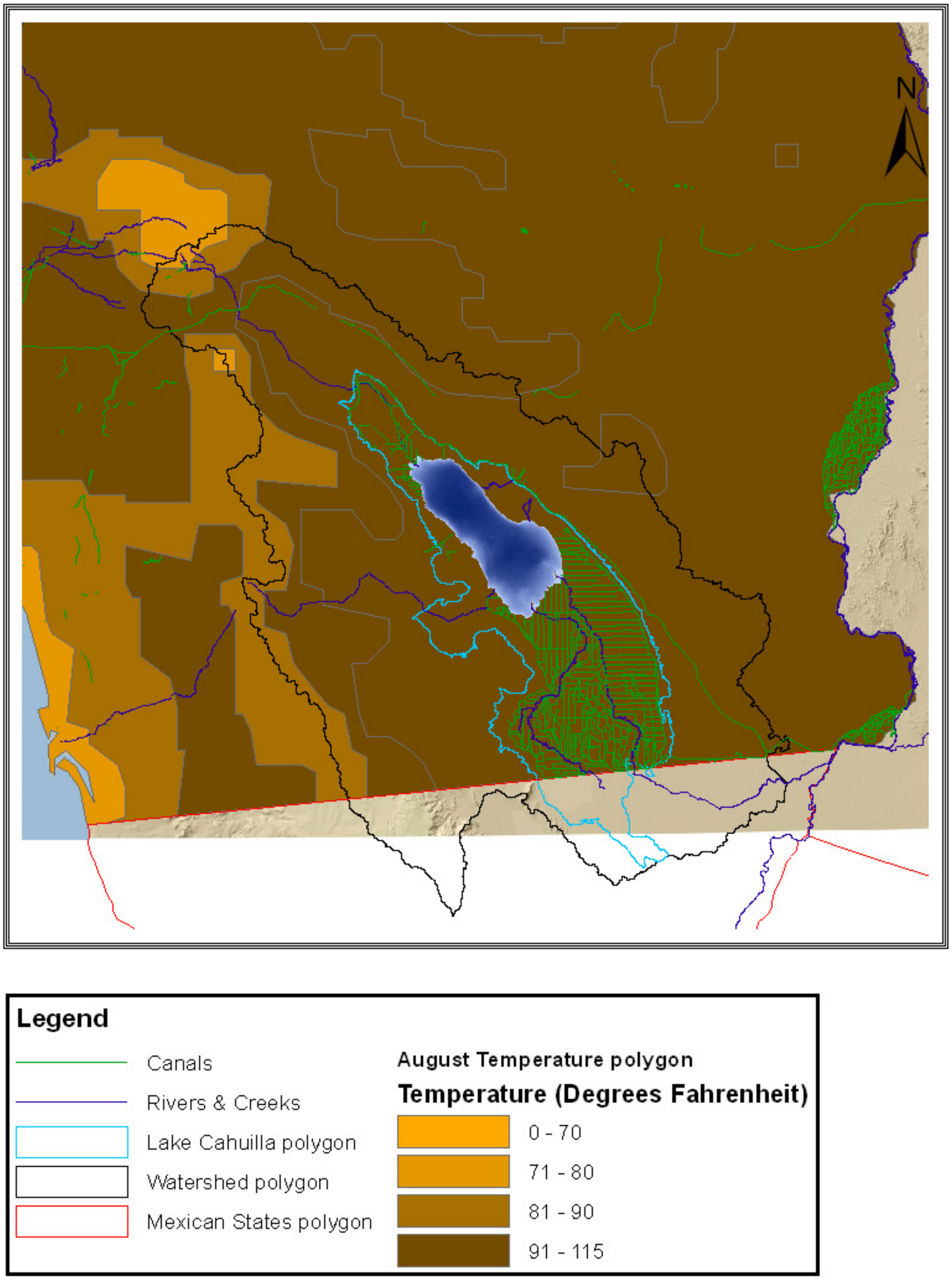


Fig. A.21 - Average August temperature in and around the Salton Sea Basin.

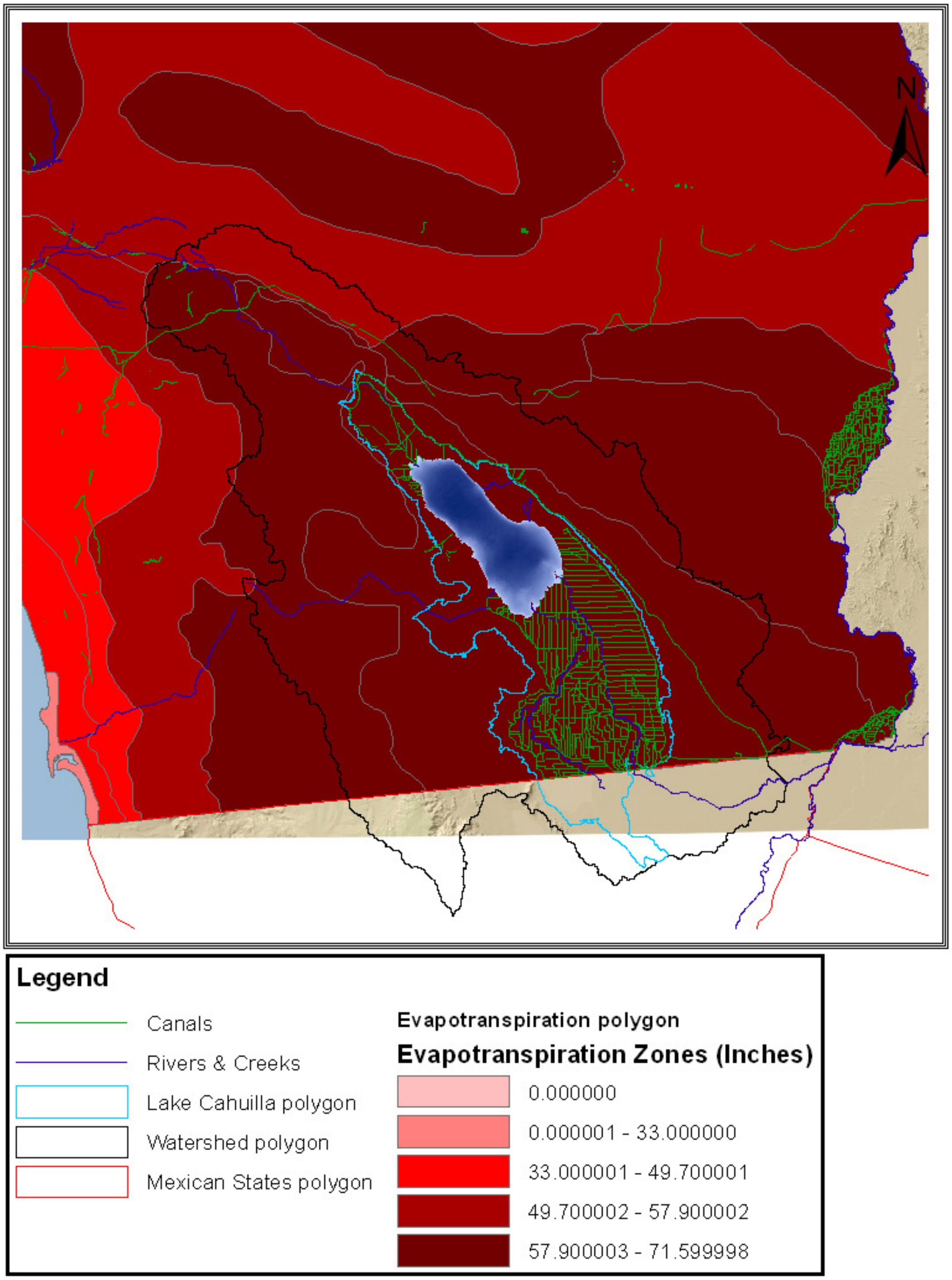


Fig. A.22 - Average annual evapotranspiration in and around the Salton Sea Basin.

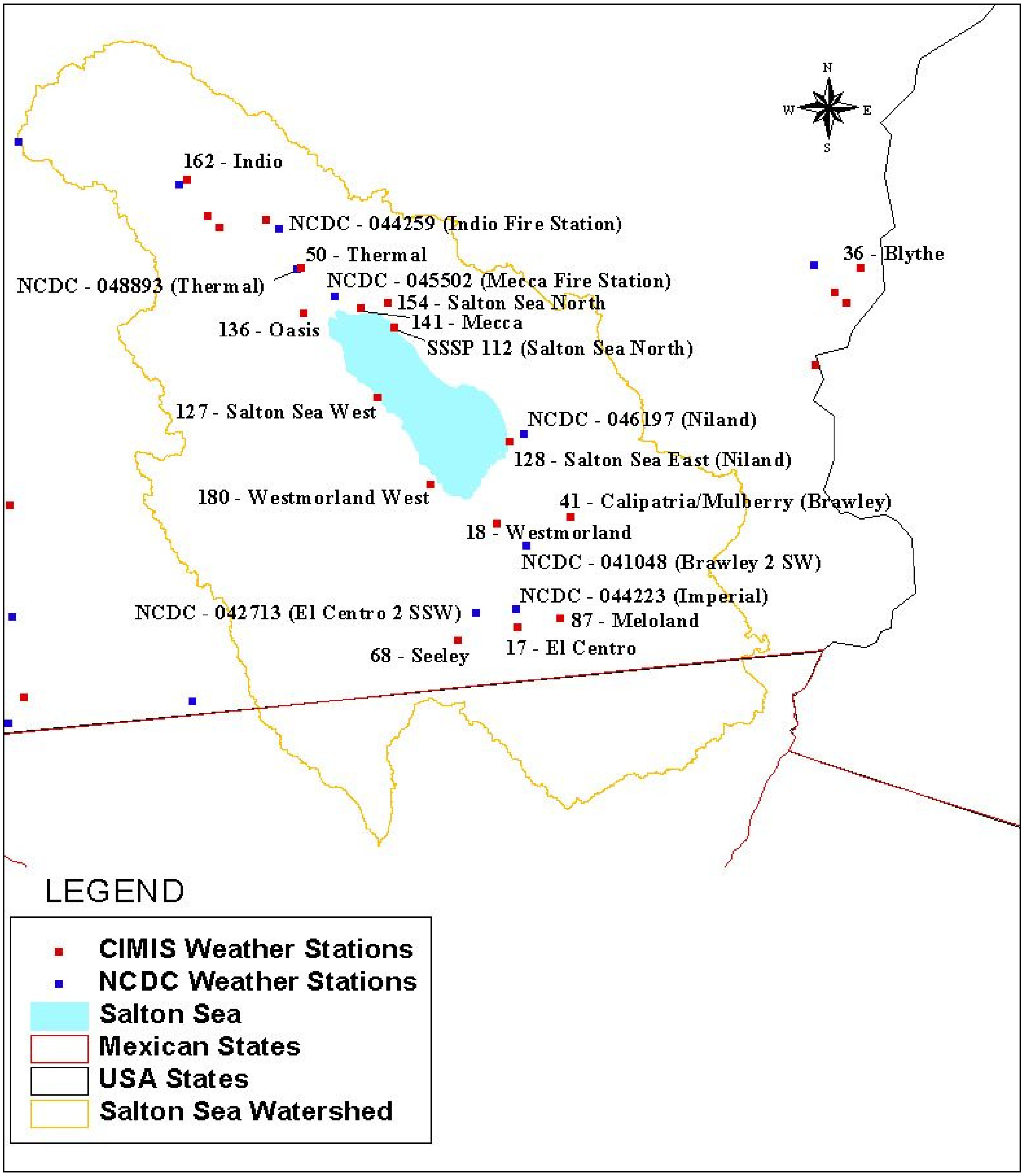


Fig. A.23 - Weather stations within the Salton Sea Basin.

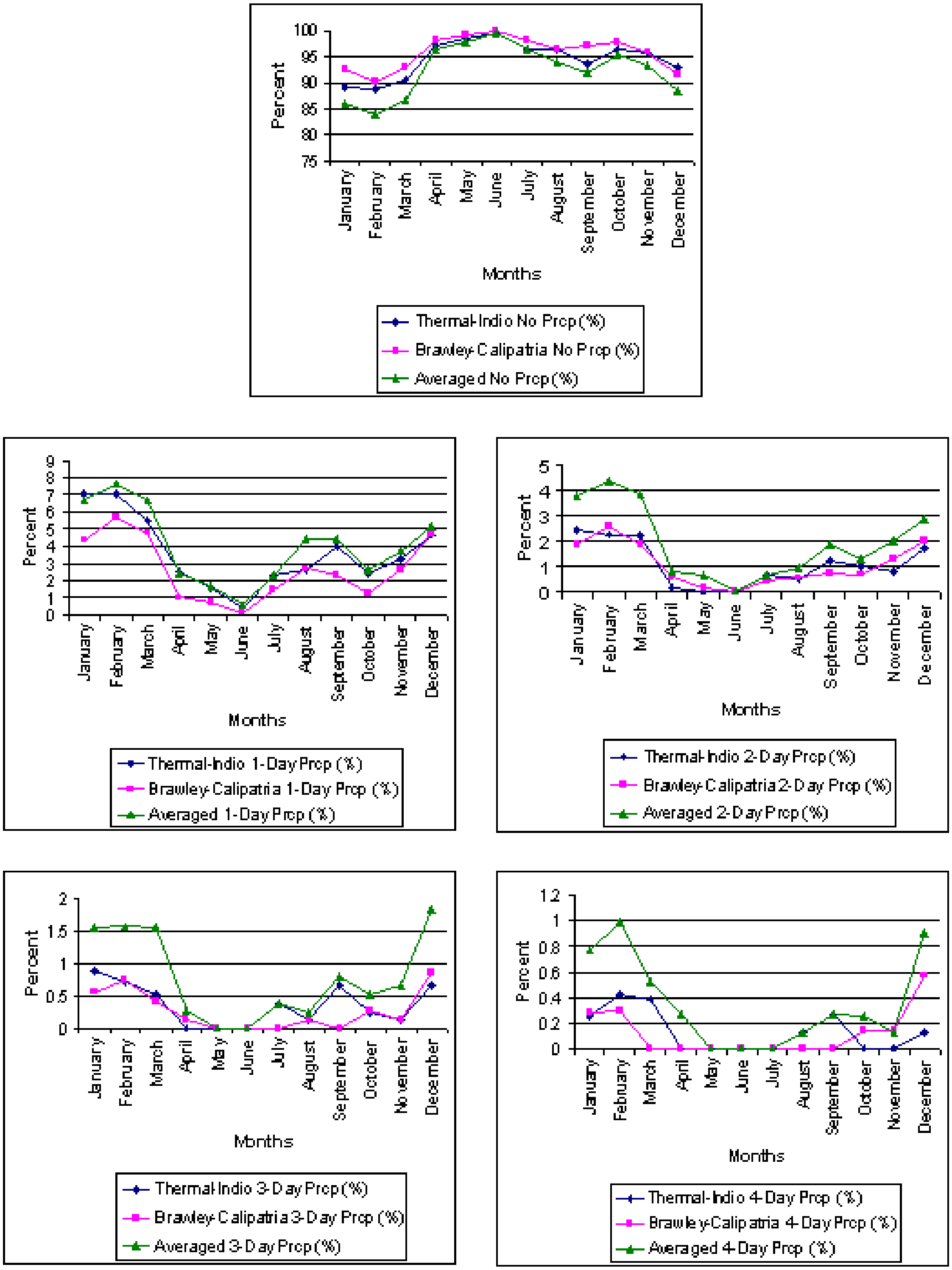


Fig. A.24 - Classification of average precipitation event duration by month, measured as a percentage of total number of events, for each weather station and their combined average.

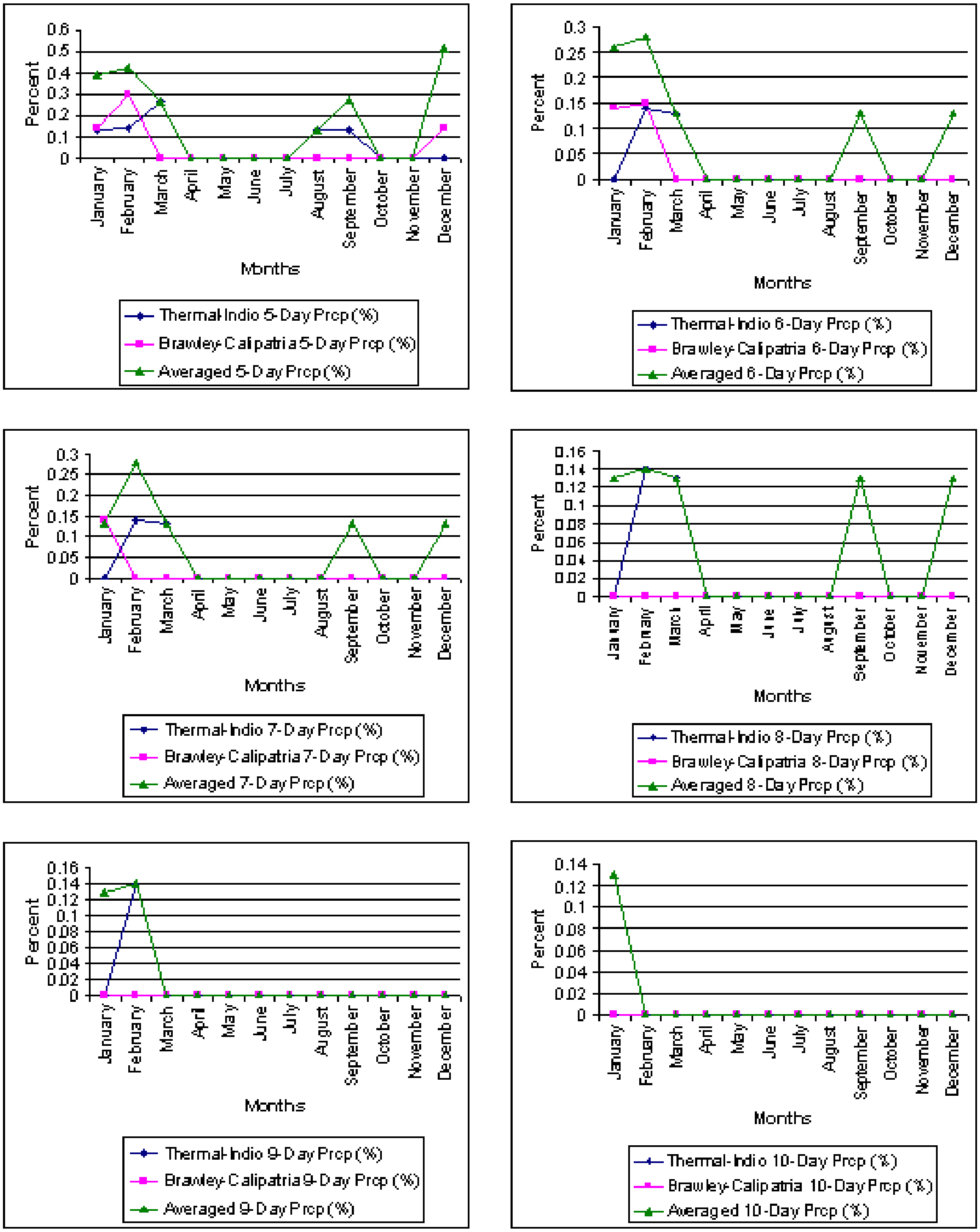


Fig. A.24 - (Continued).

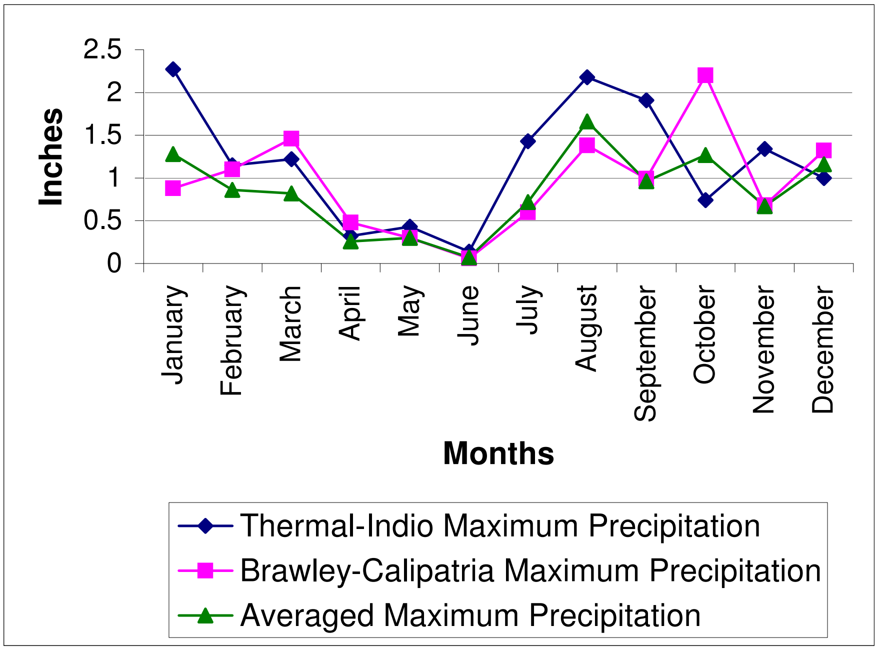


Fig. A.25 - Averaged precipitation volumes by month for each weather station and their combined average.

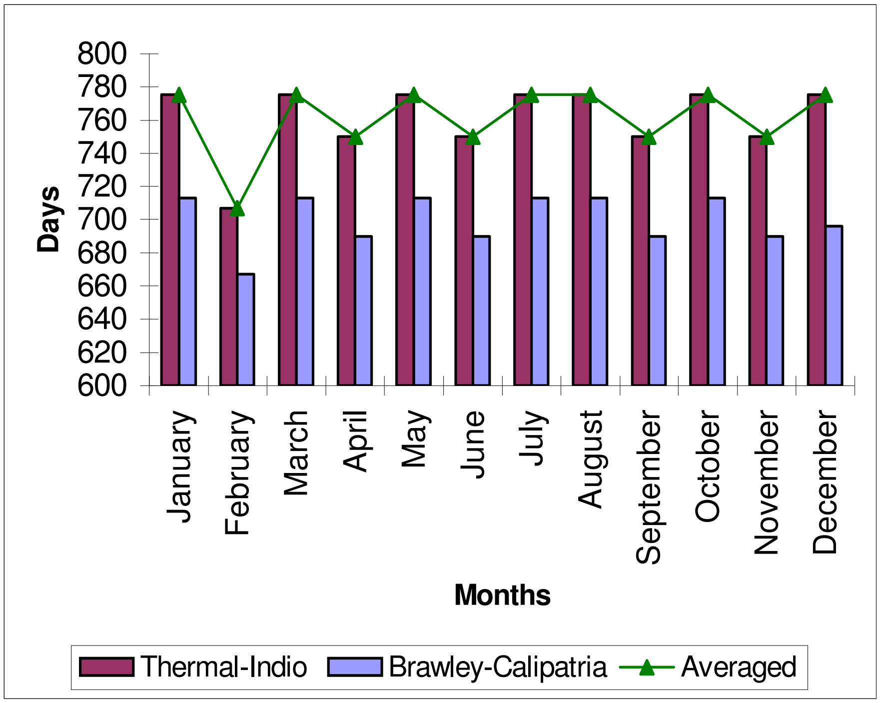


Fig. A.26 - Available daily precipitation observation data by month.

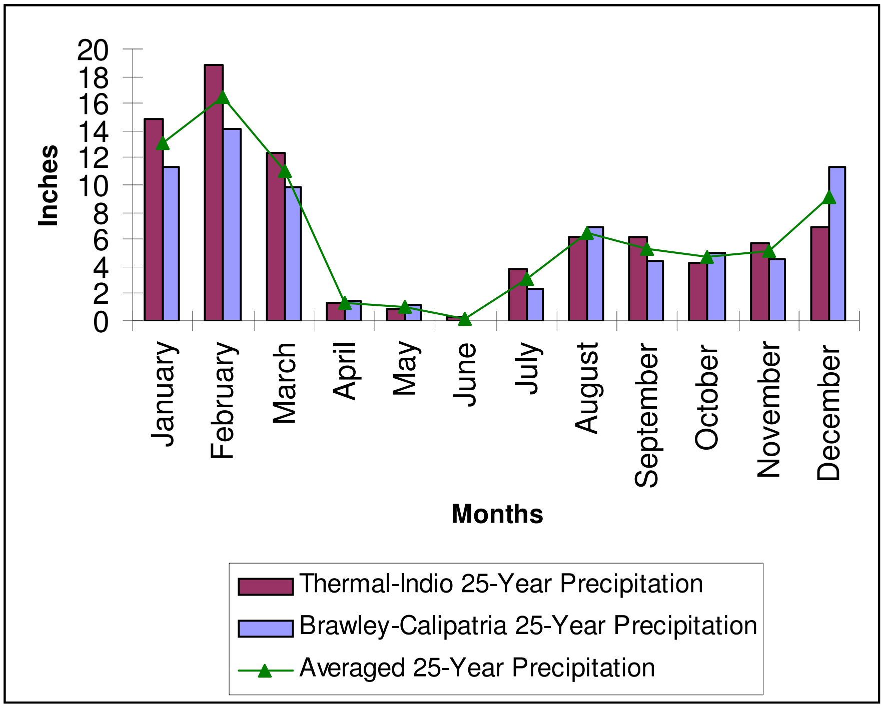


Fig. A.27 - Total precipitation volumes per month for each weather station and their combined average.

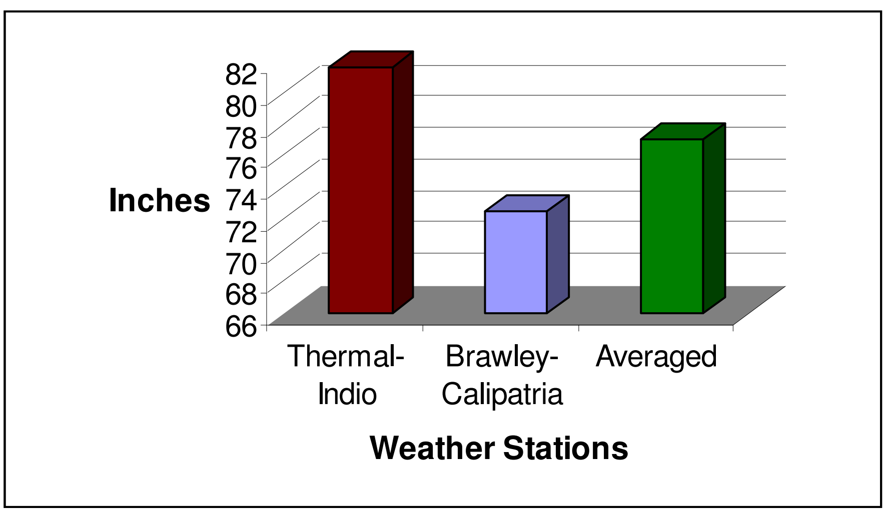


Fig. A.28 - Total 25-year period precipitation volumes for each weather station and their combined average.

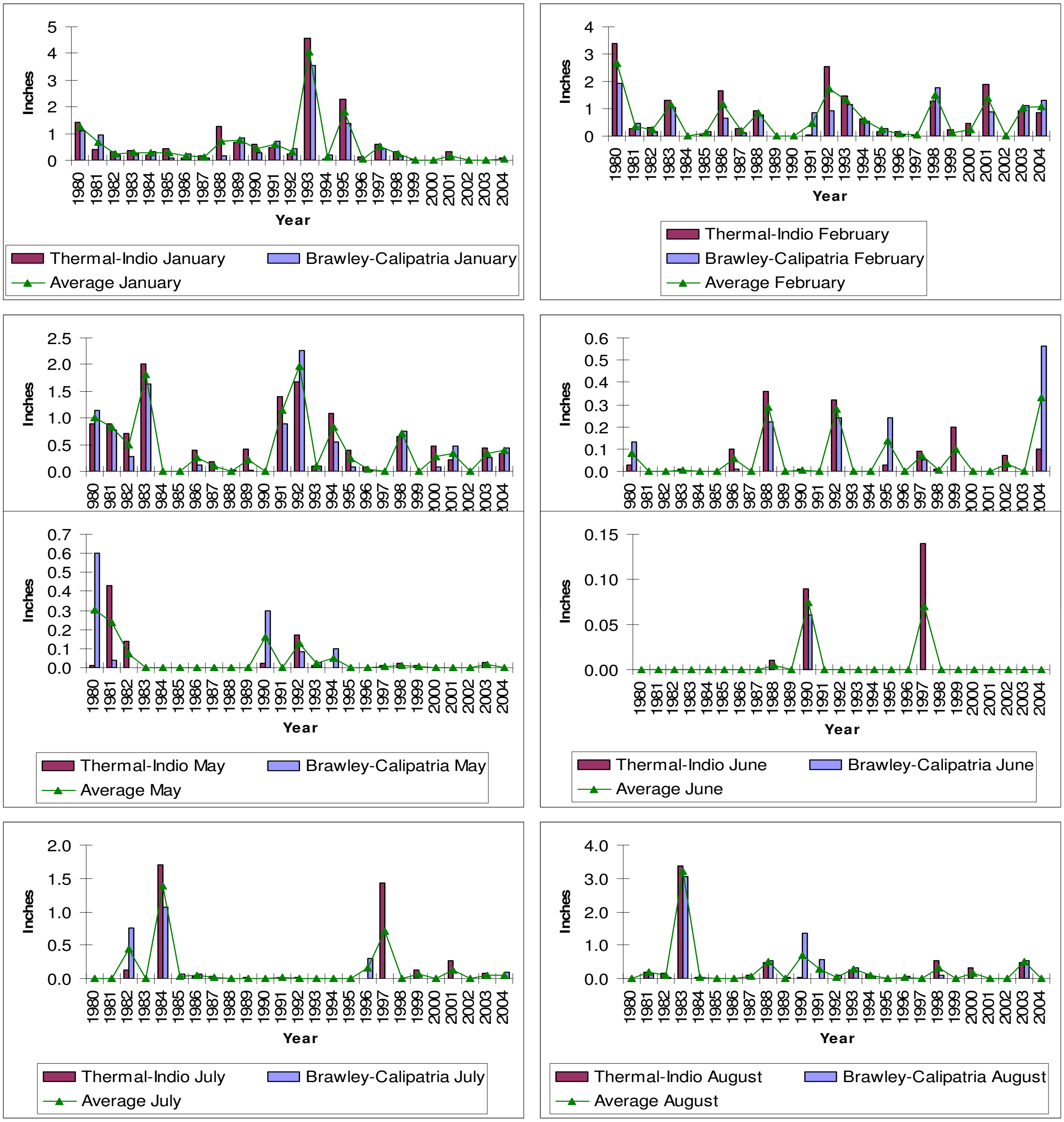
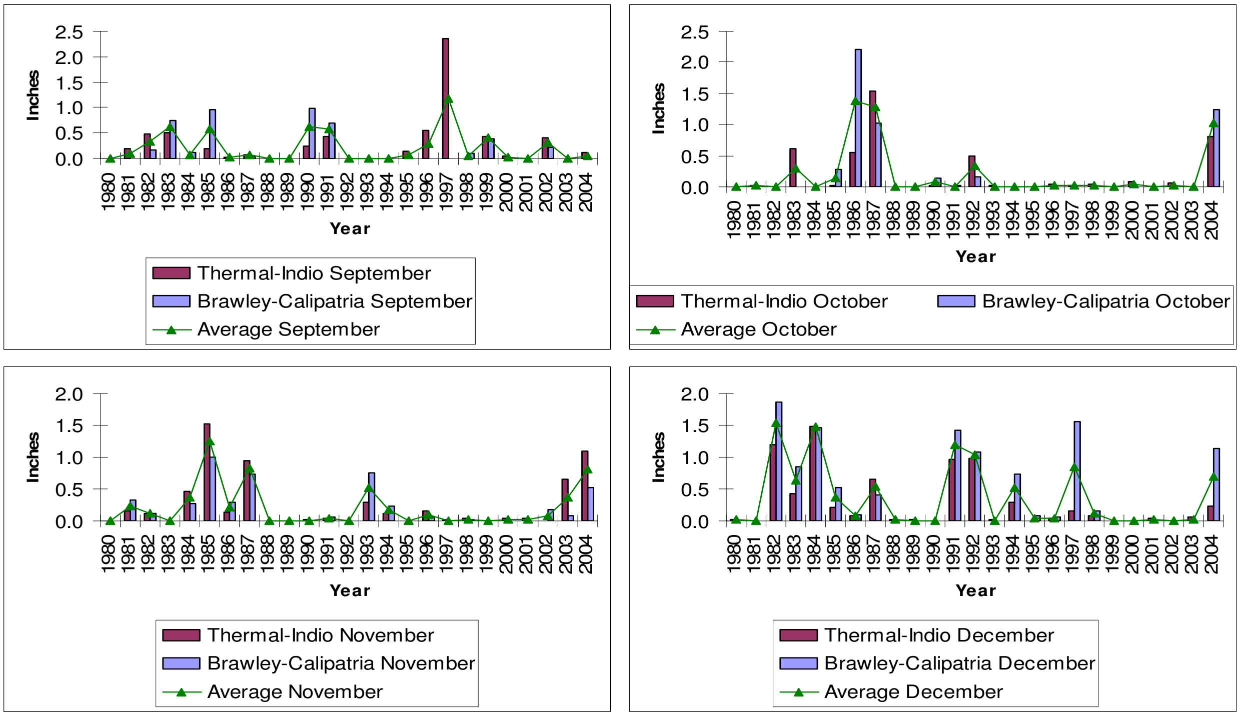


Fig. A.29 - Total 25-year period annual precipitation volumes by month.



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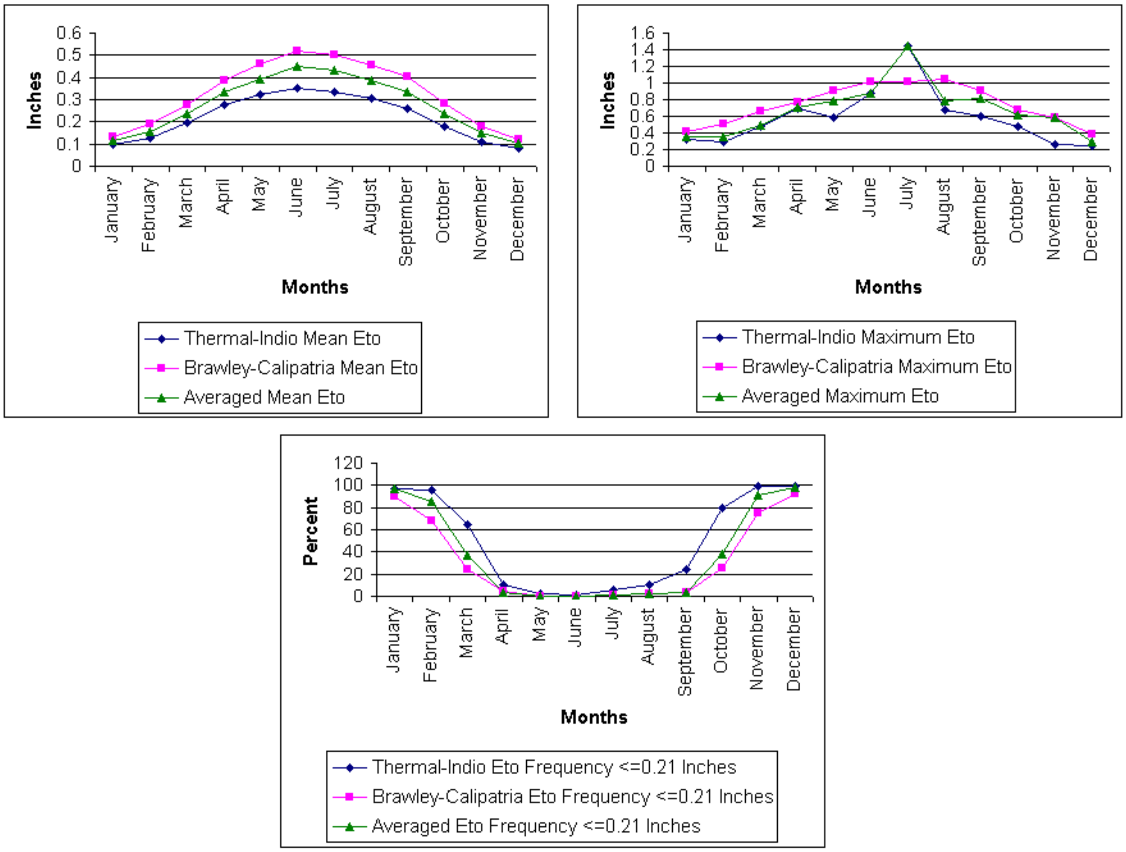


Fig. A.30 - Comparison of mean, maximum, and evapotranspiration (Eto) frequency ≤ 0.21 inches by month for each weather station and their combined average.

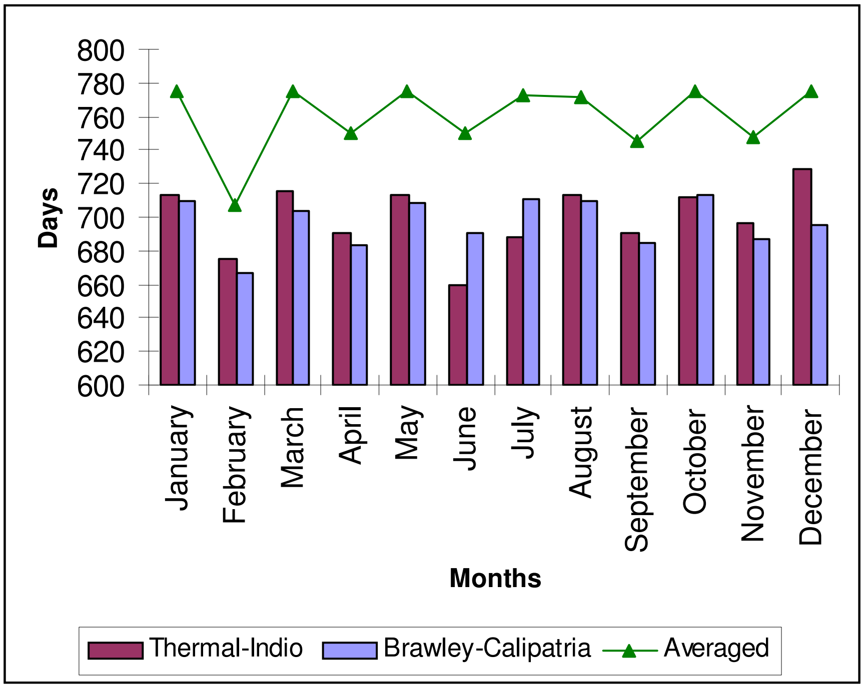


Fig. A.31 - Available daily evapotranspiration (Eto) observation data by month for each weather station and their combined average.

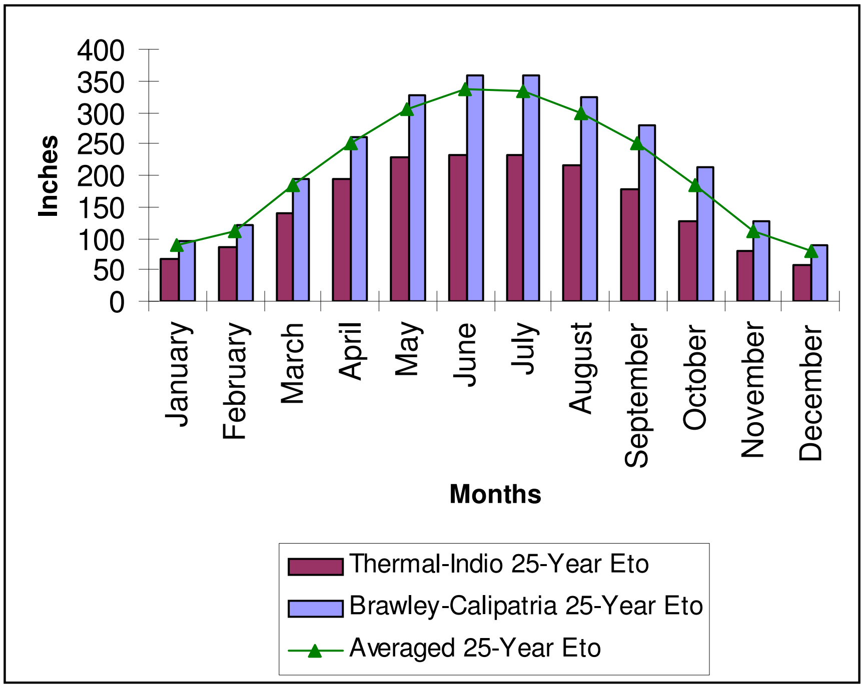


Fig. A.32 - Total evapotranspiration volumes by month for each weather station and their combined average.

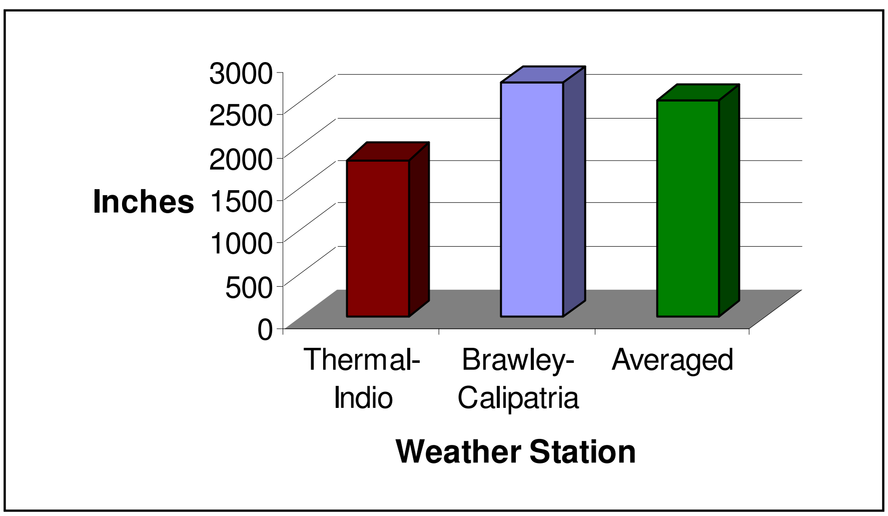


Fig. A.33 - Total 25-year period evapotranspiration volumes for each weather station and their combined average.

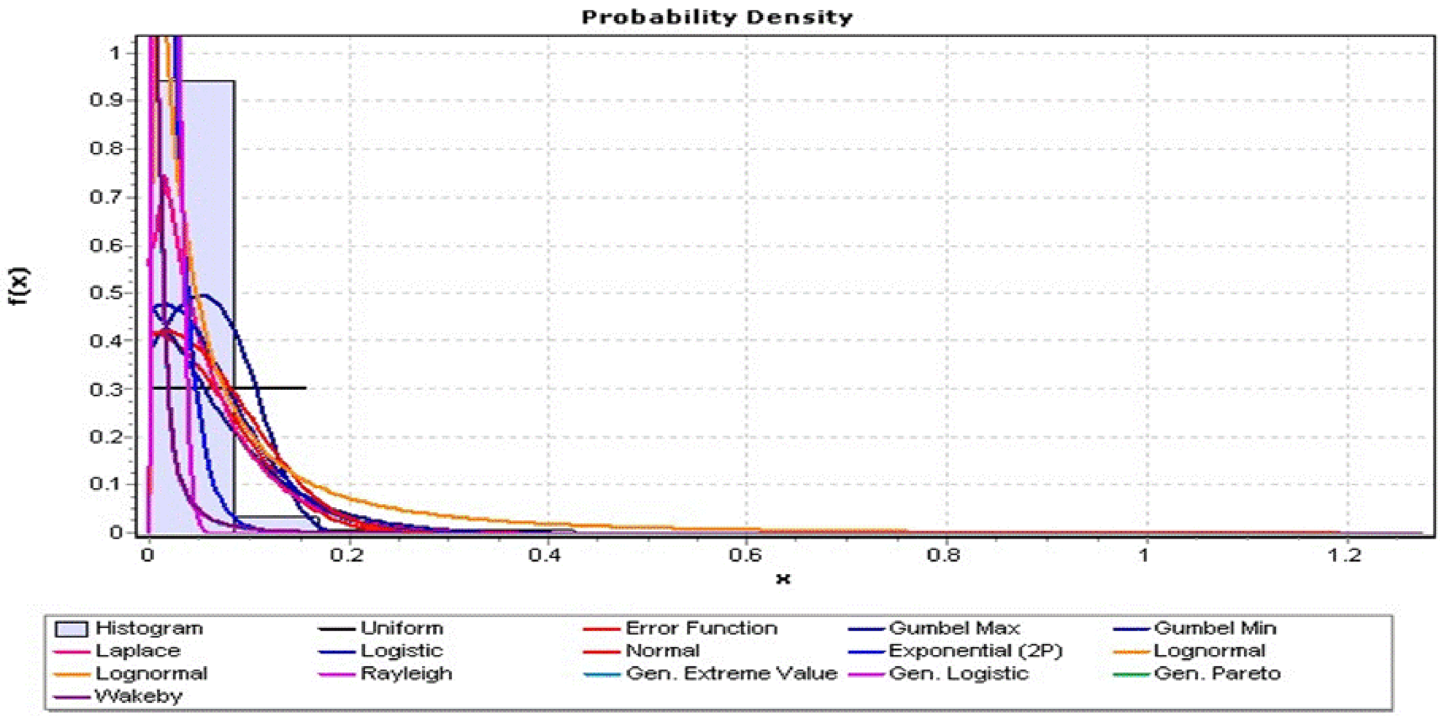
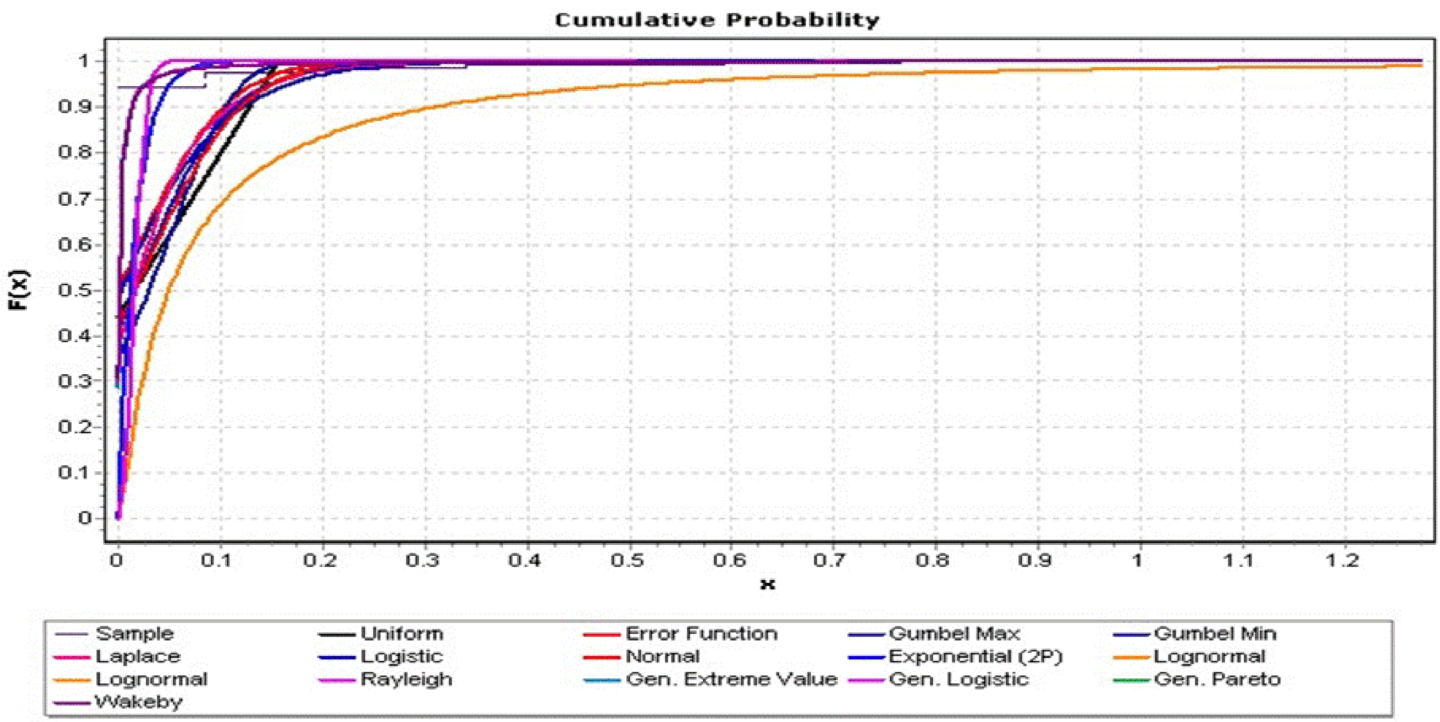


Fig. A.34 - Historic frequency distribution of averaged precipitation for January.



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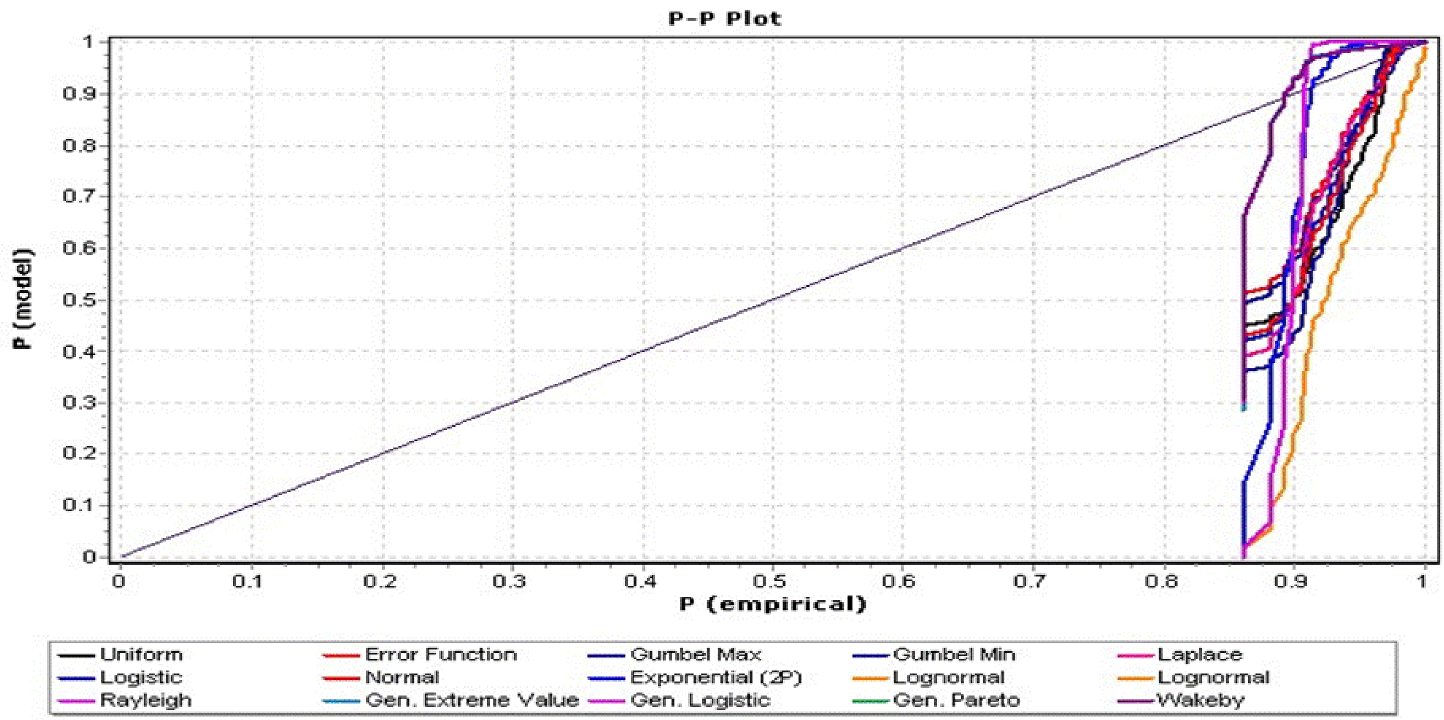

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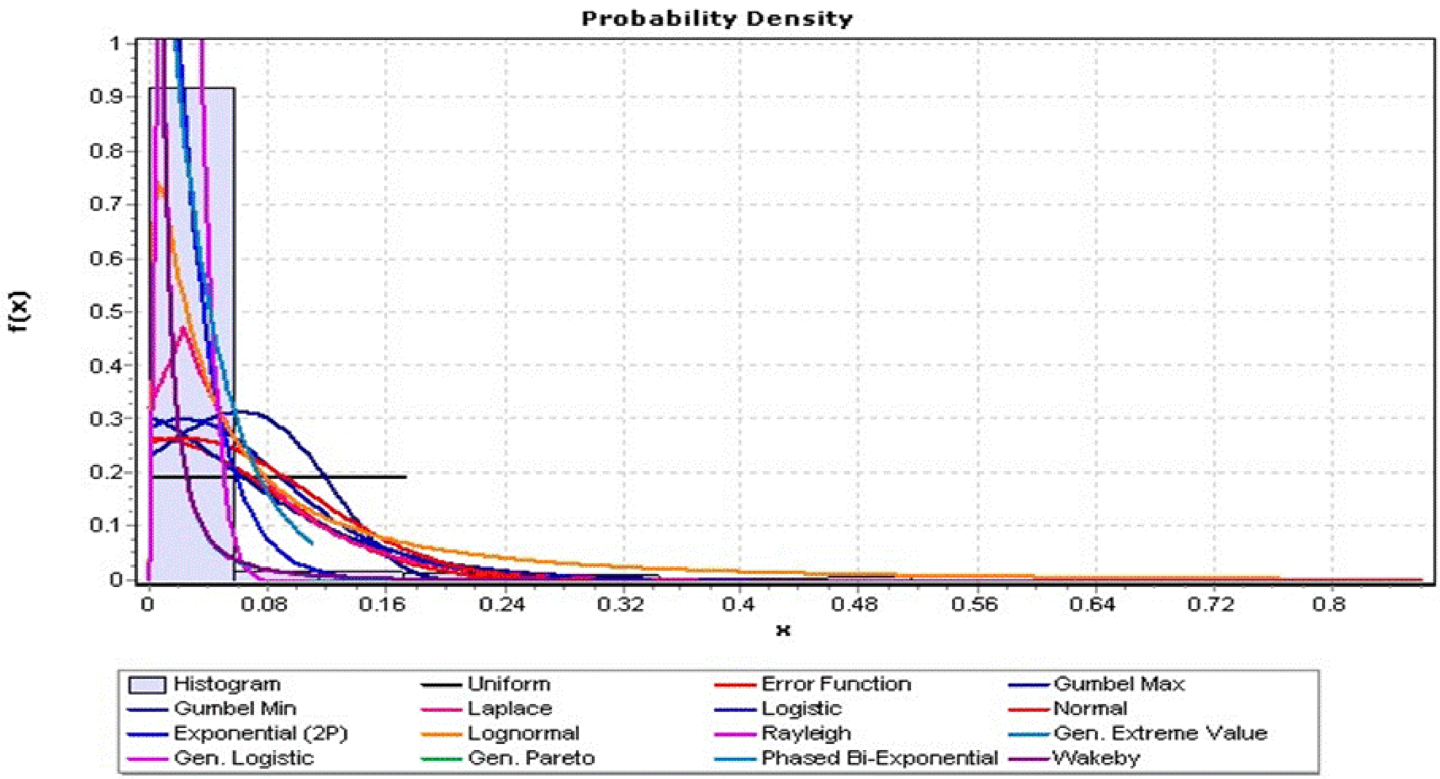
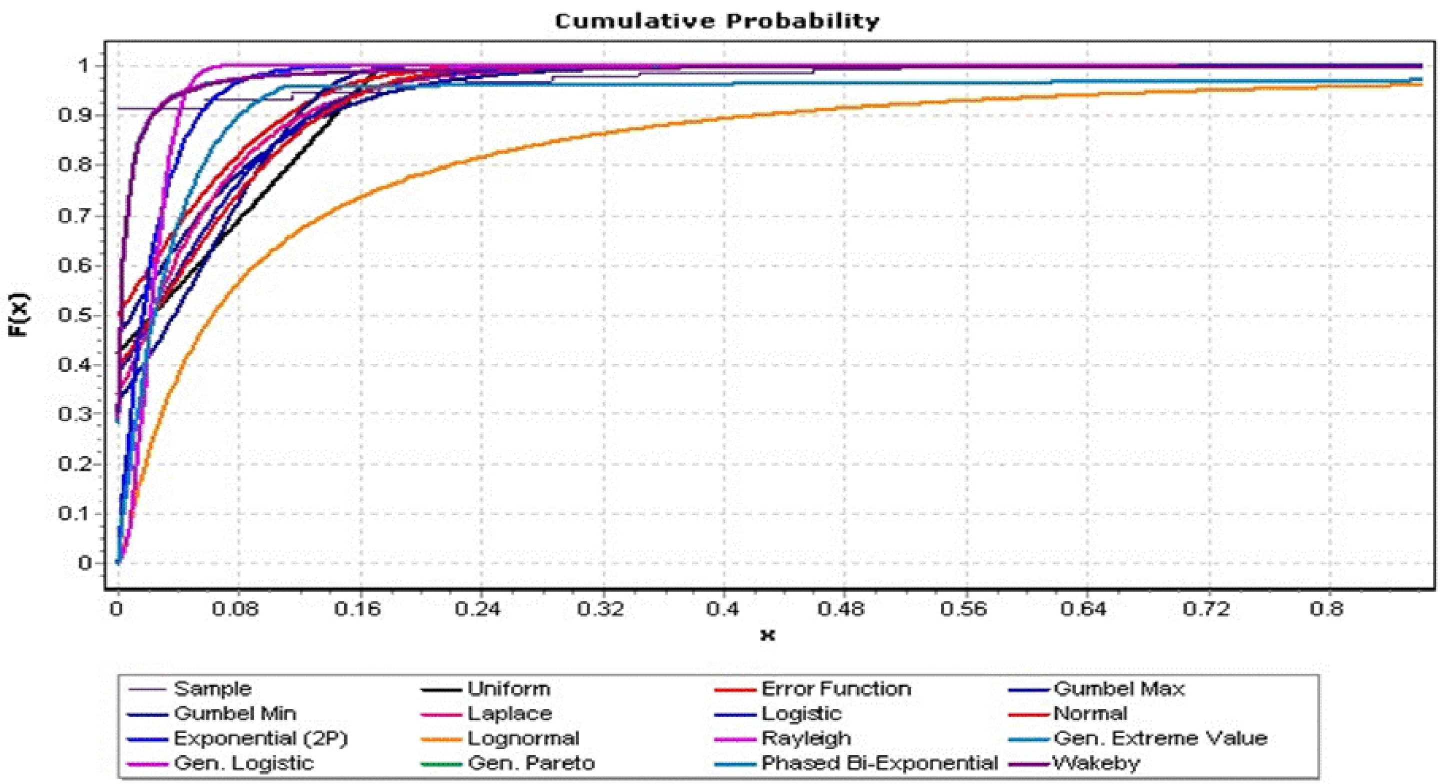


Fig. A.35 - Historic frequency distribution of averaged precipitation for February.



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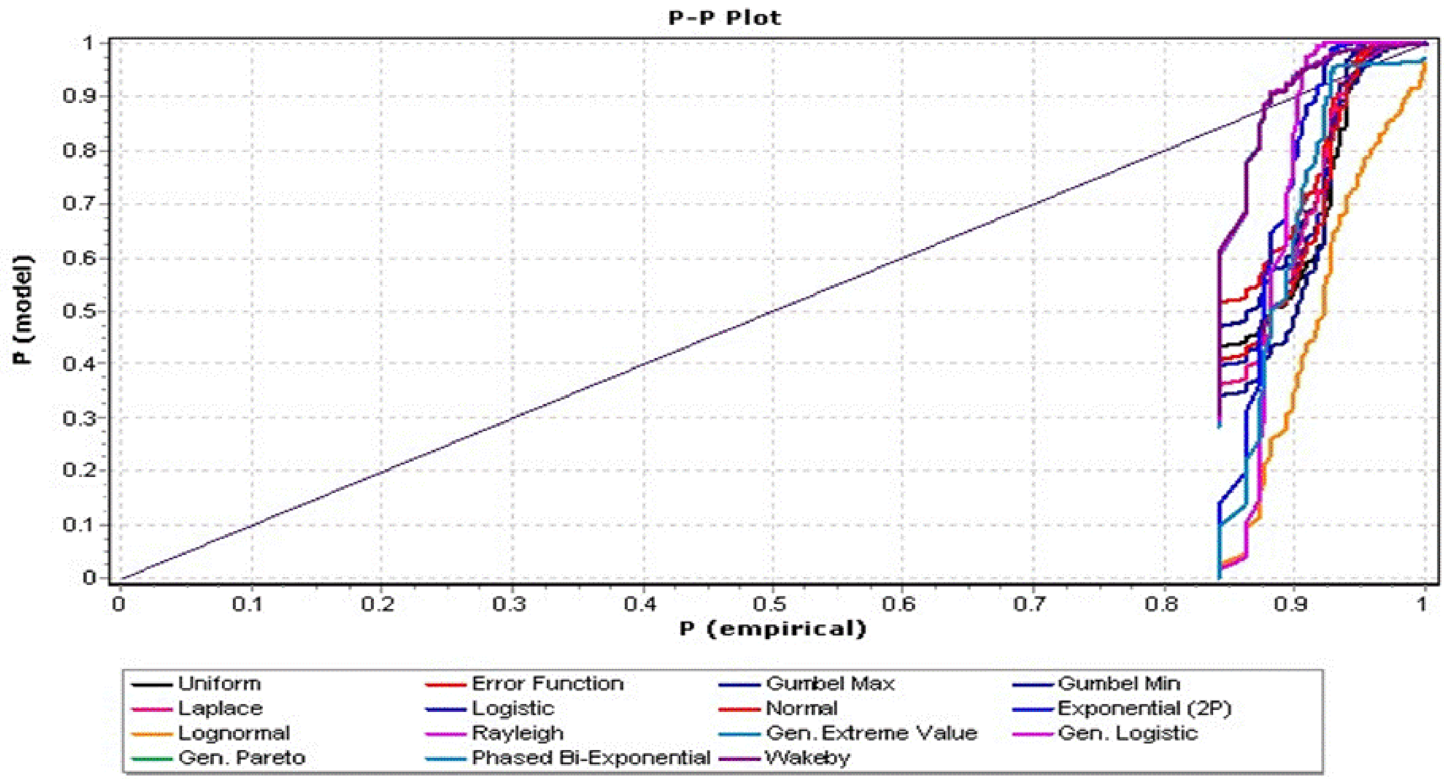

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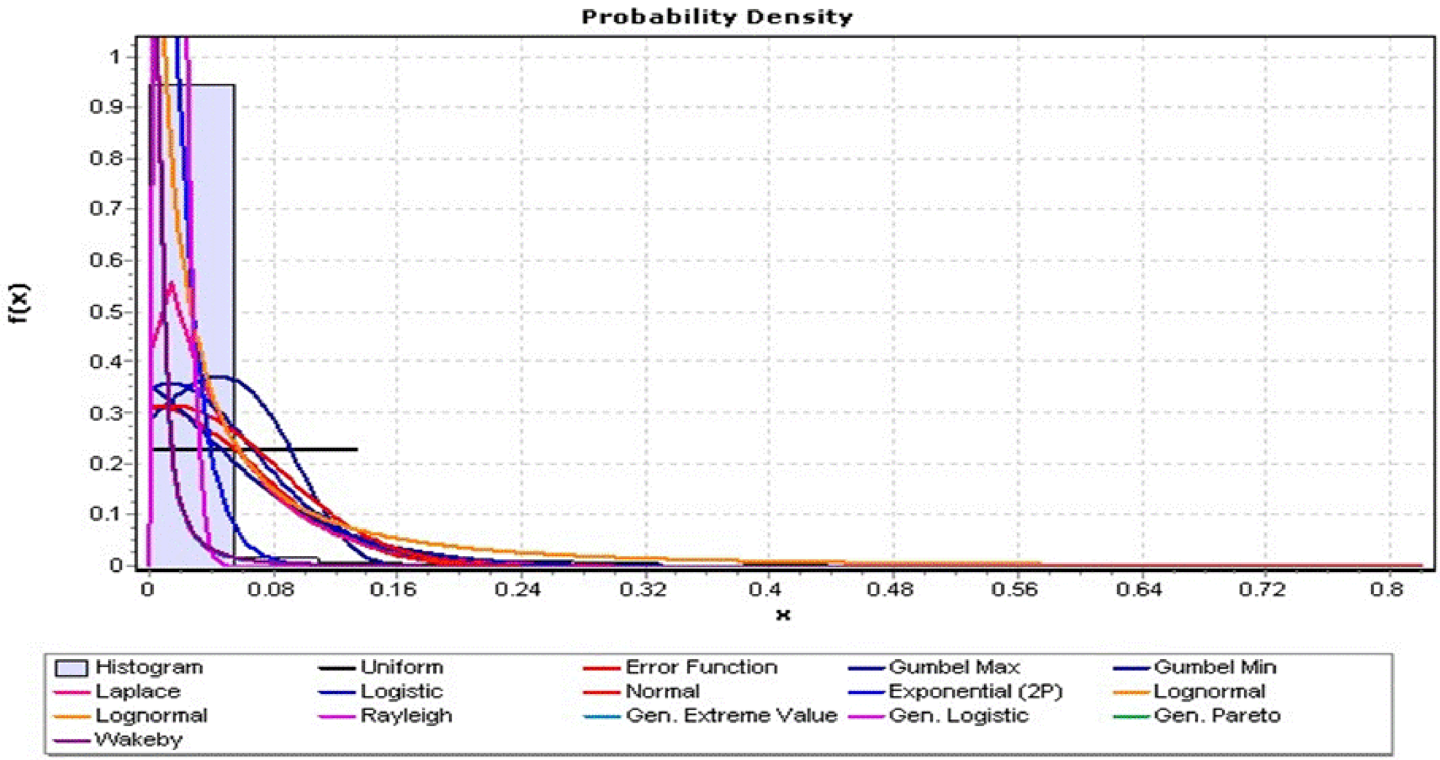
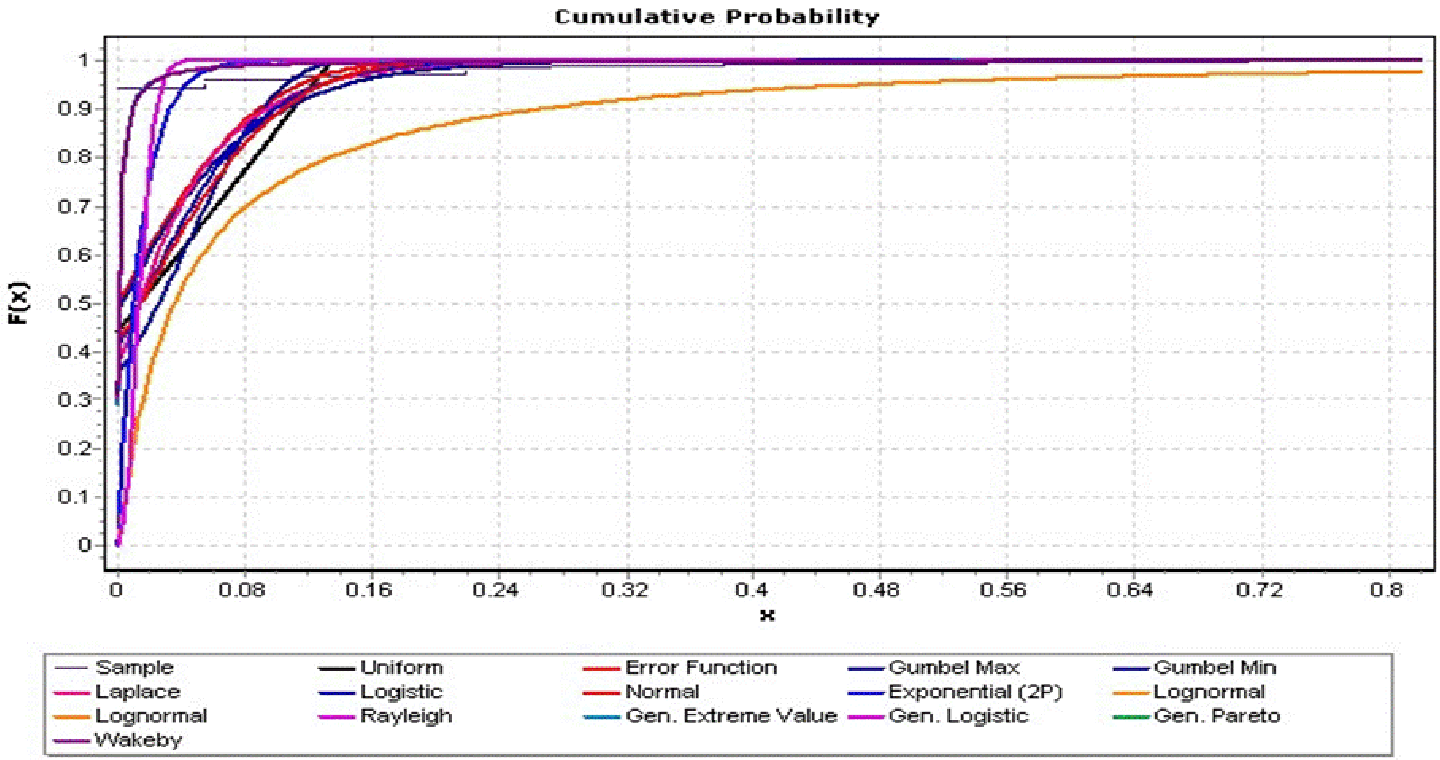


Fig. A.36 - Historic frequency distribution of averaged precipitation for March.



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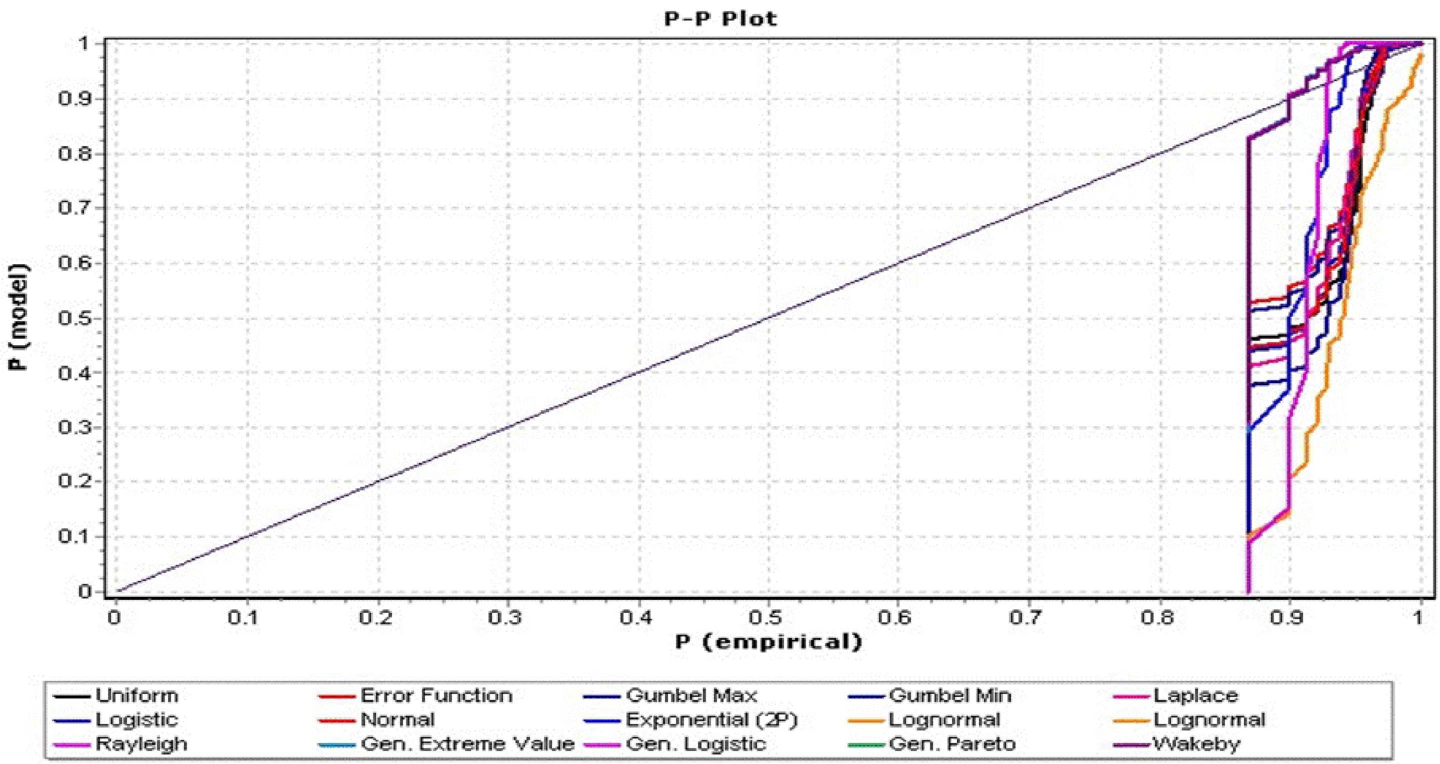

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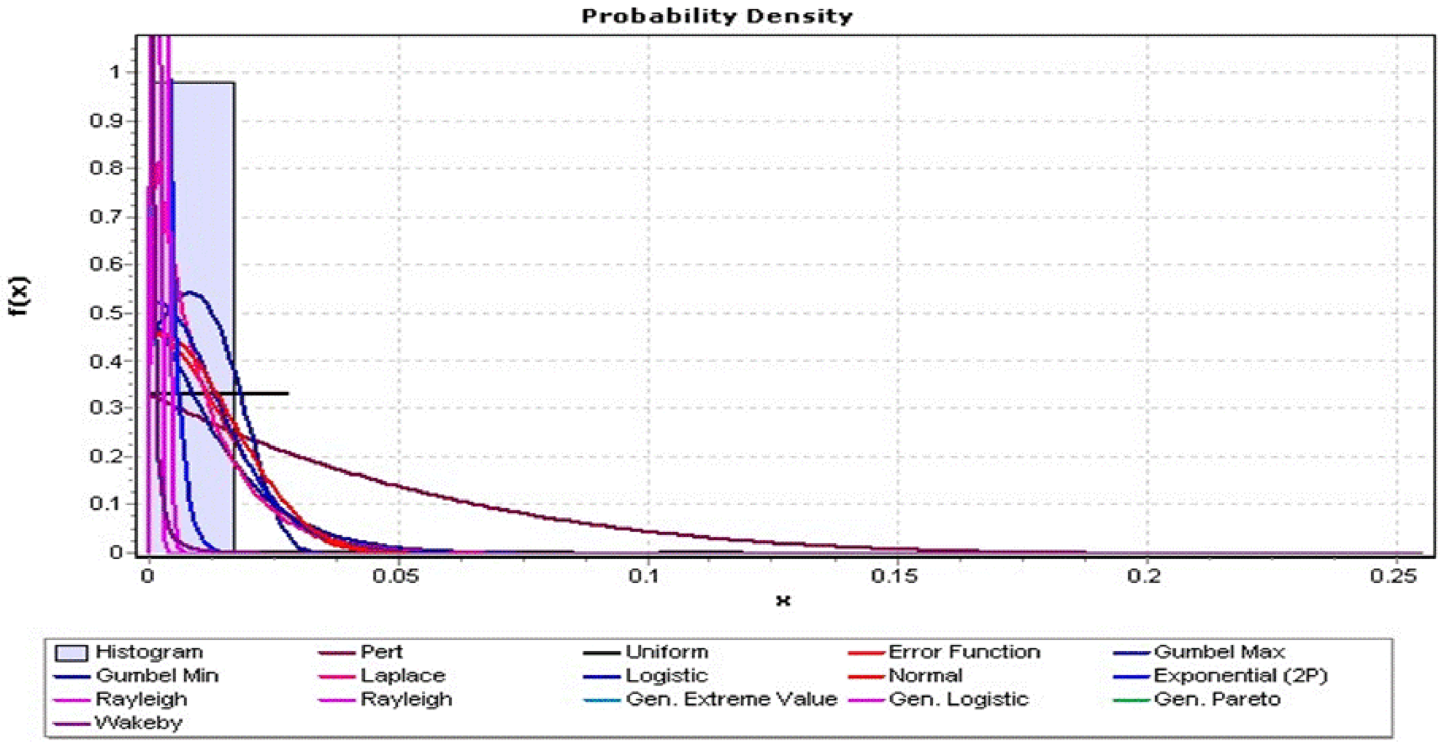
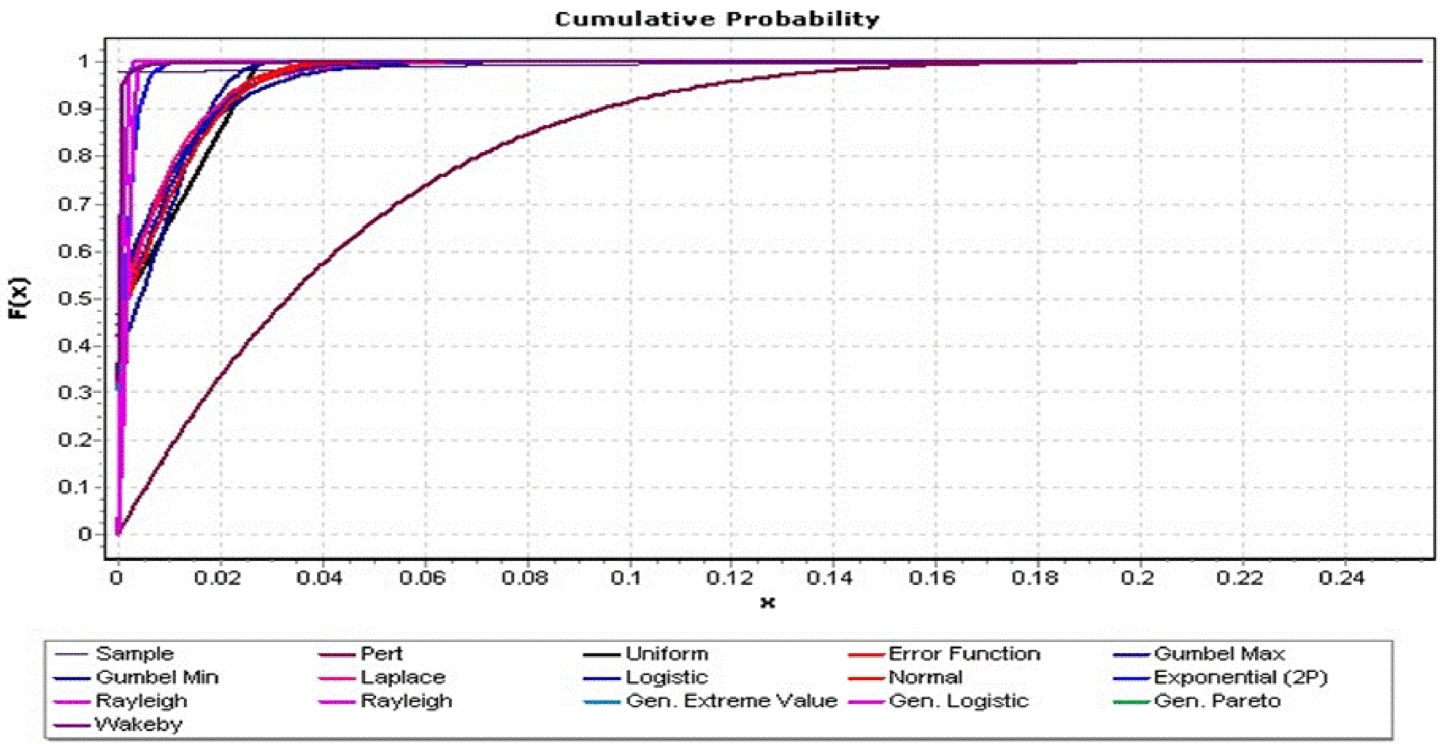


Fig. A.37 - Historic frequency distribution of averaged precipitation for April.



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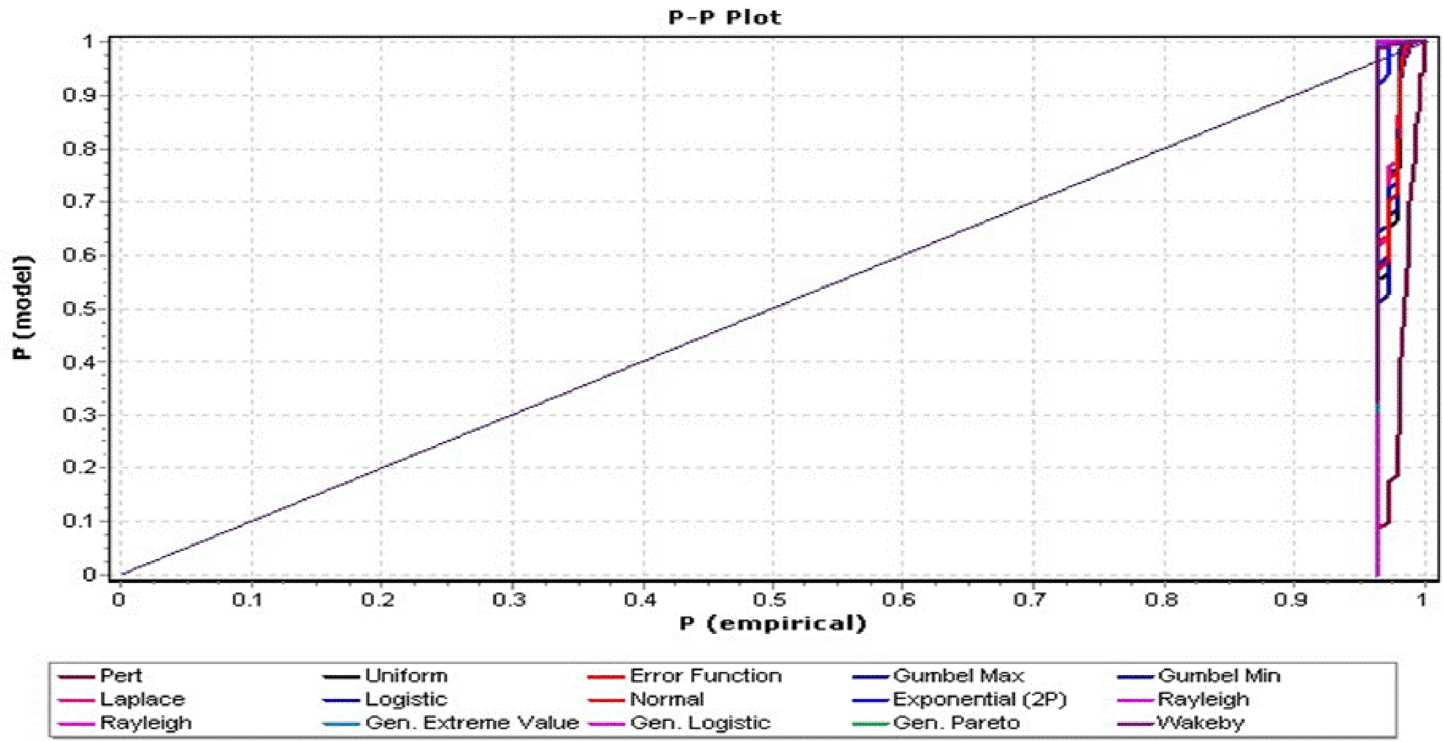

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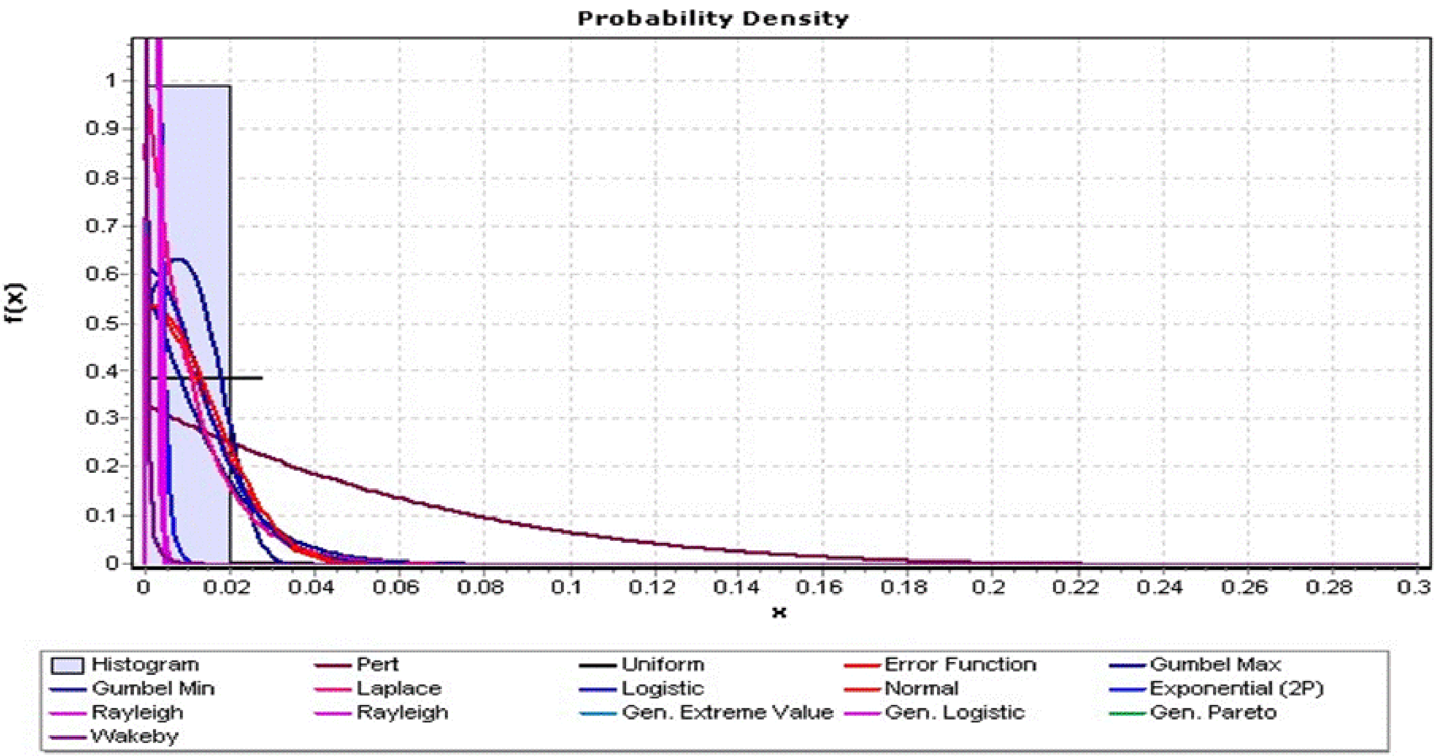
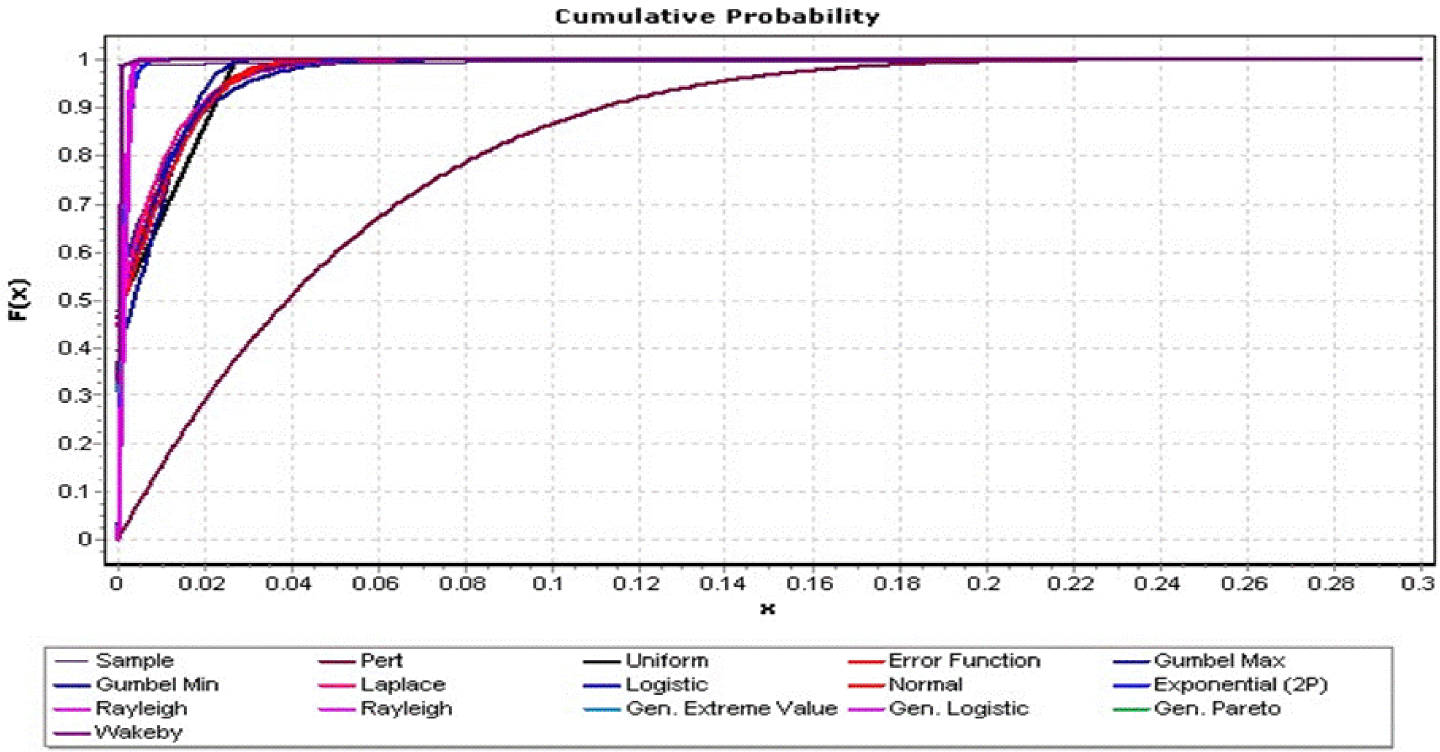


Fig. A.38 - Historic frequency distribution of averaged precipitation for May.



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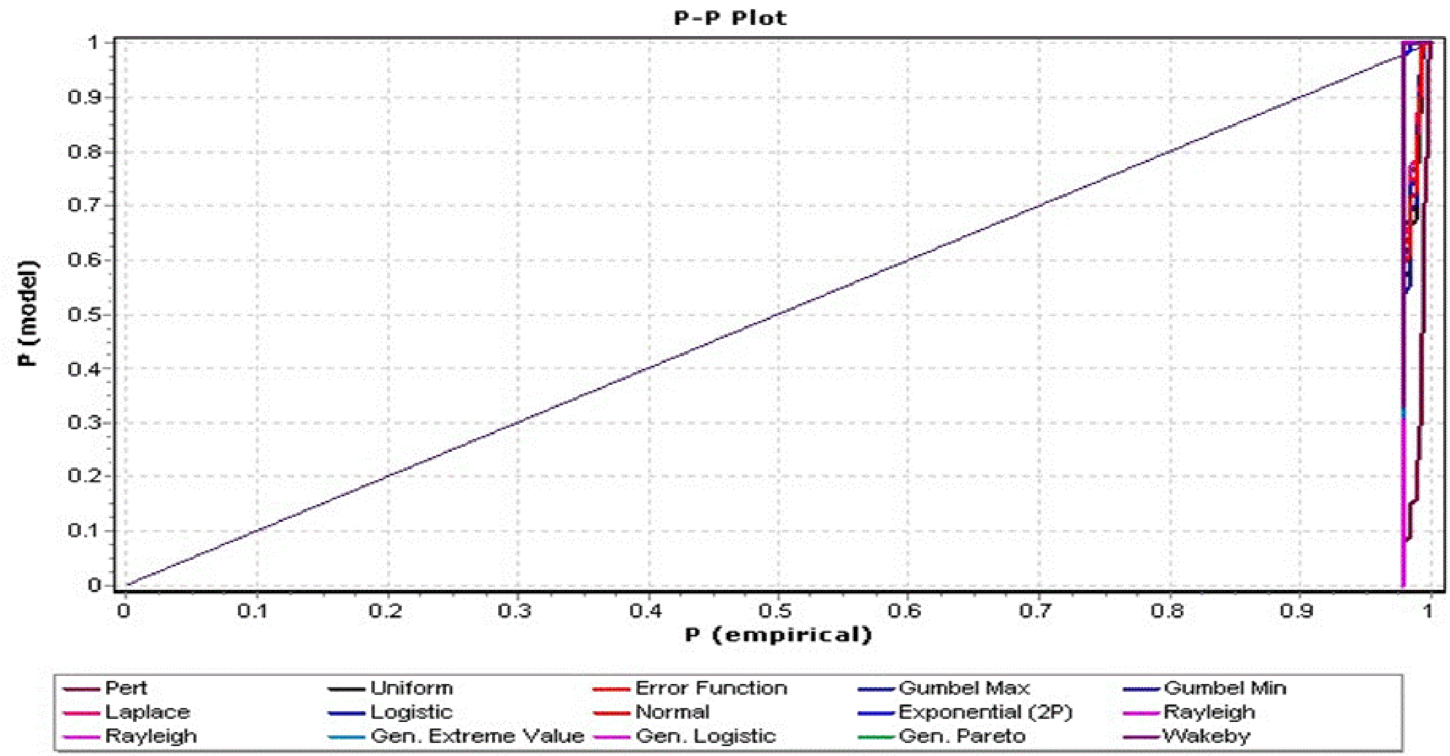

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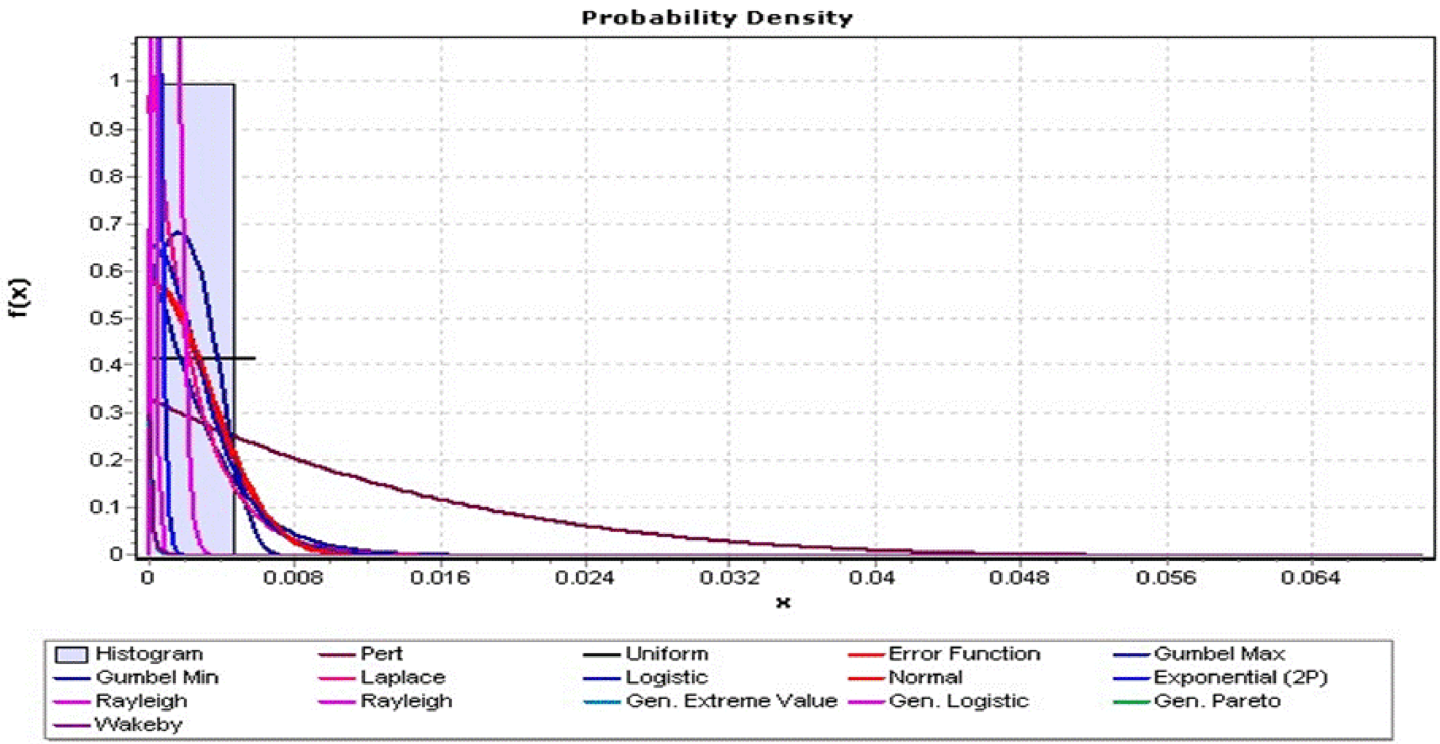
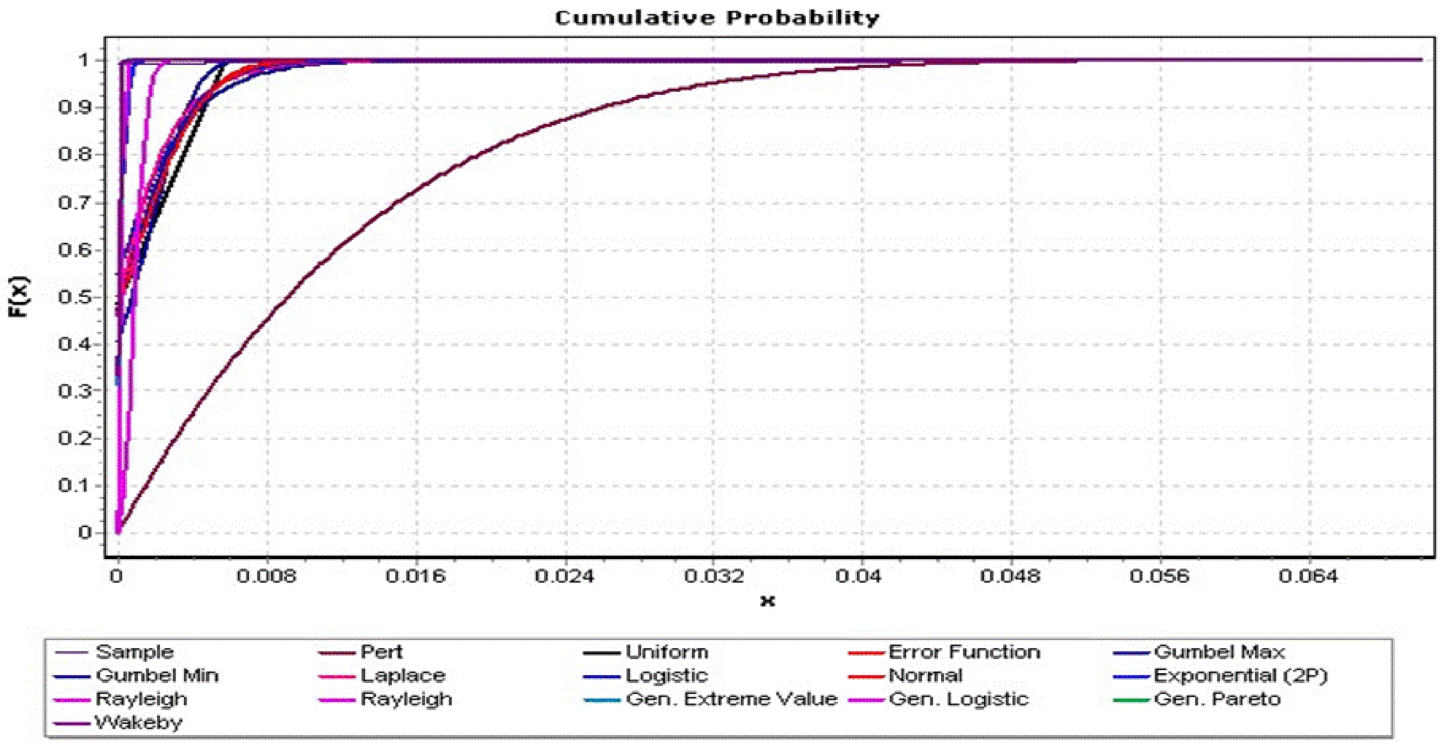


Fig. A.39 - Historic frequency distribution of averaged precipitation for June.



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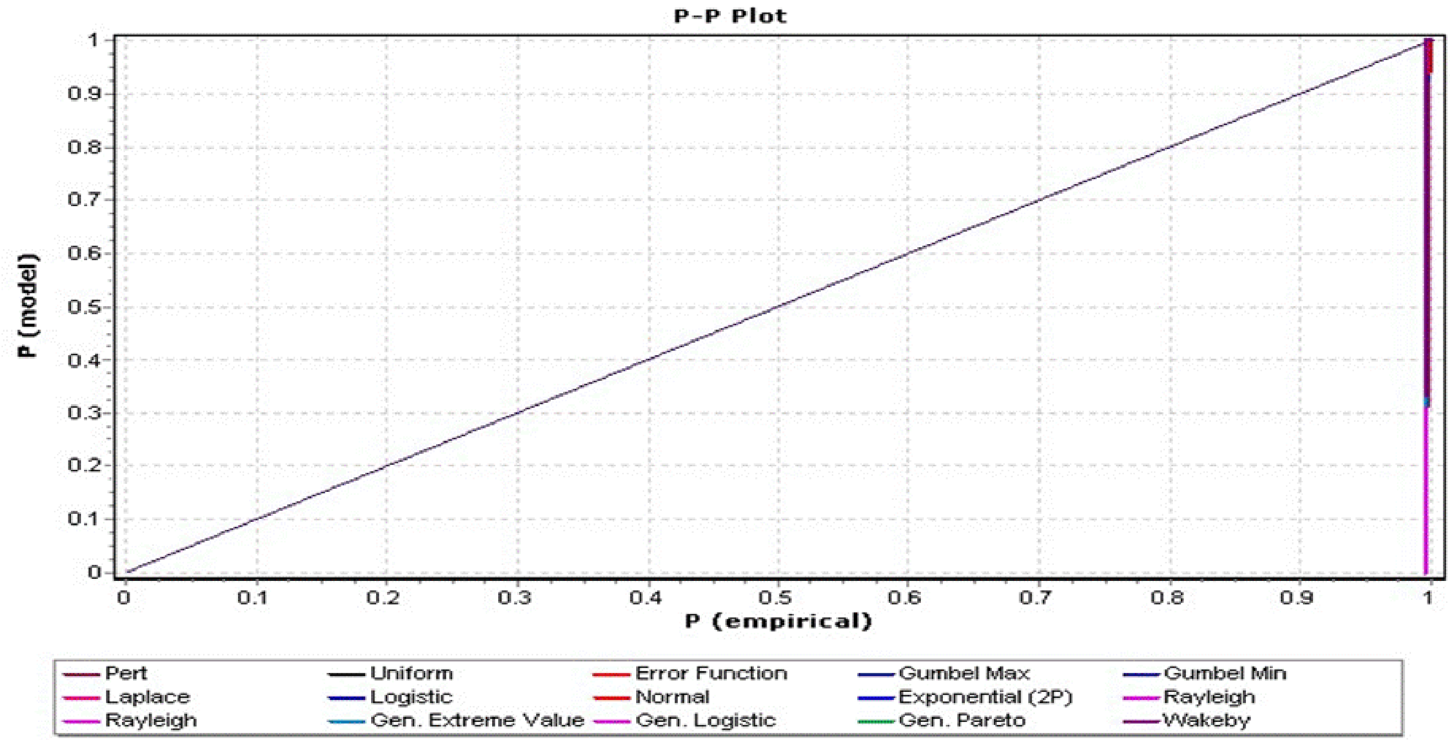

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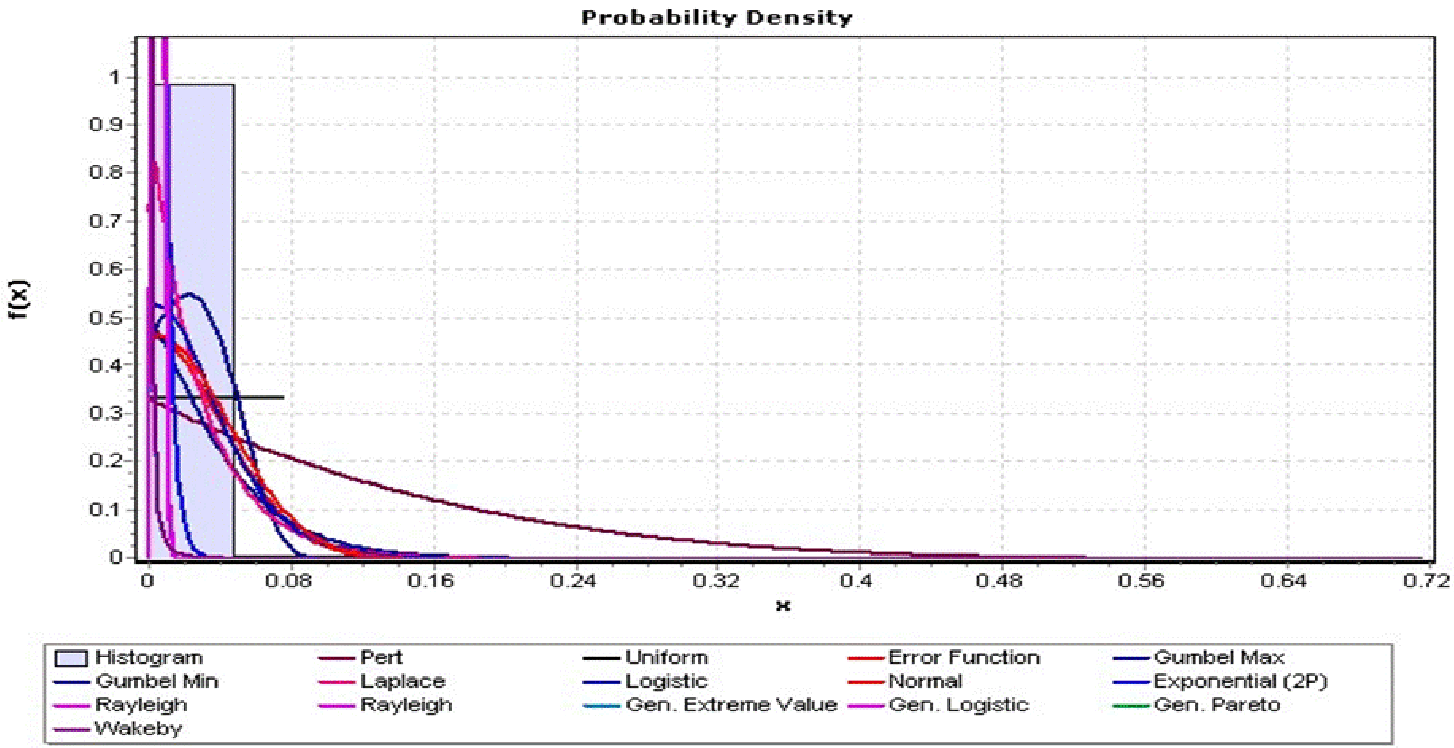
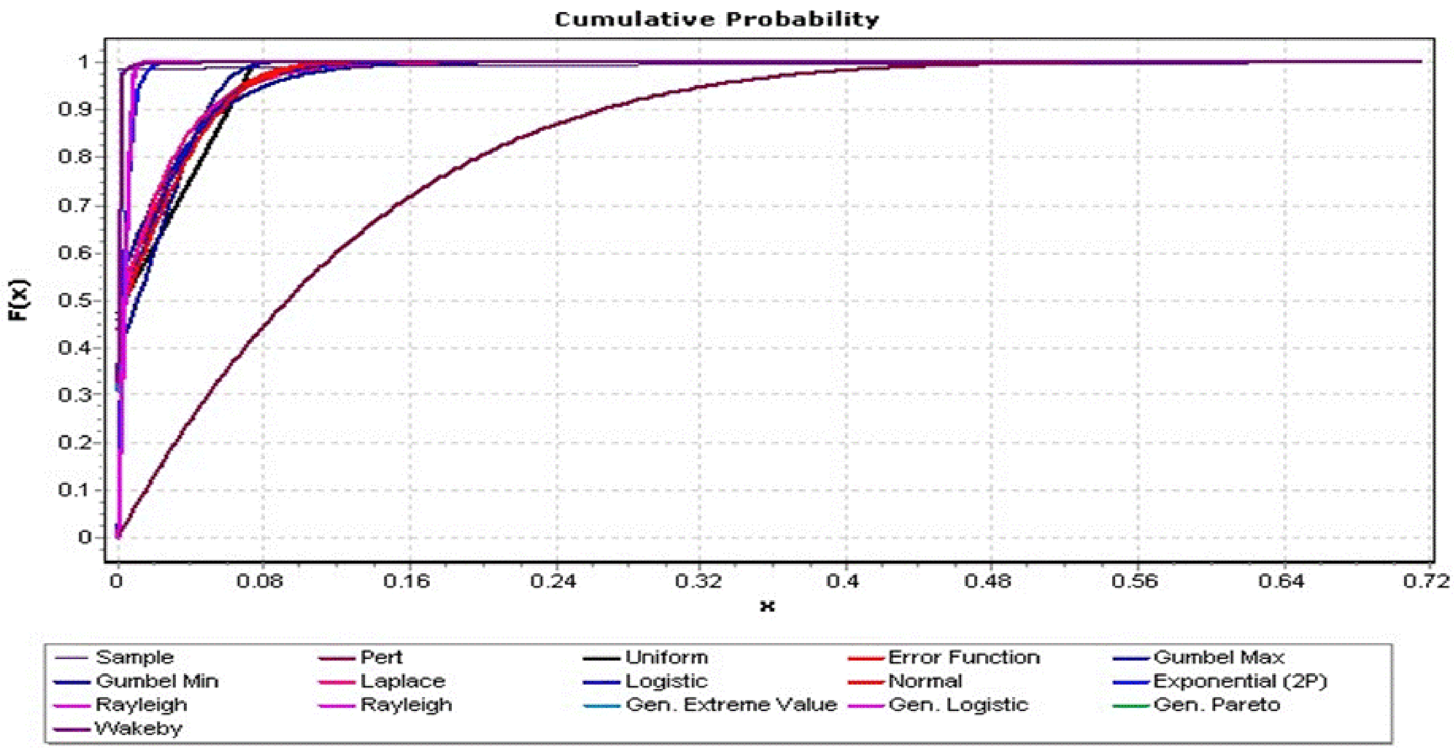


Fig. A.40 - Historic frequency distribution of averaged precipitation for July.



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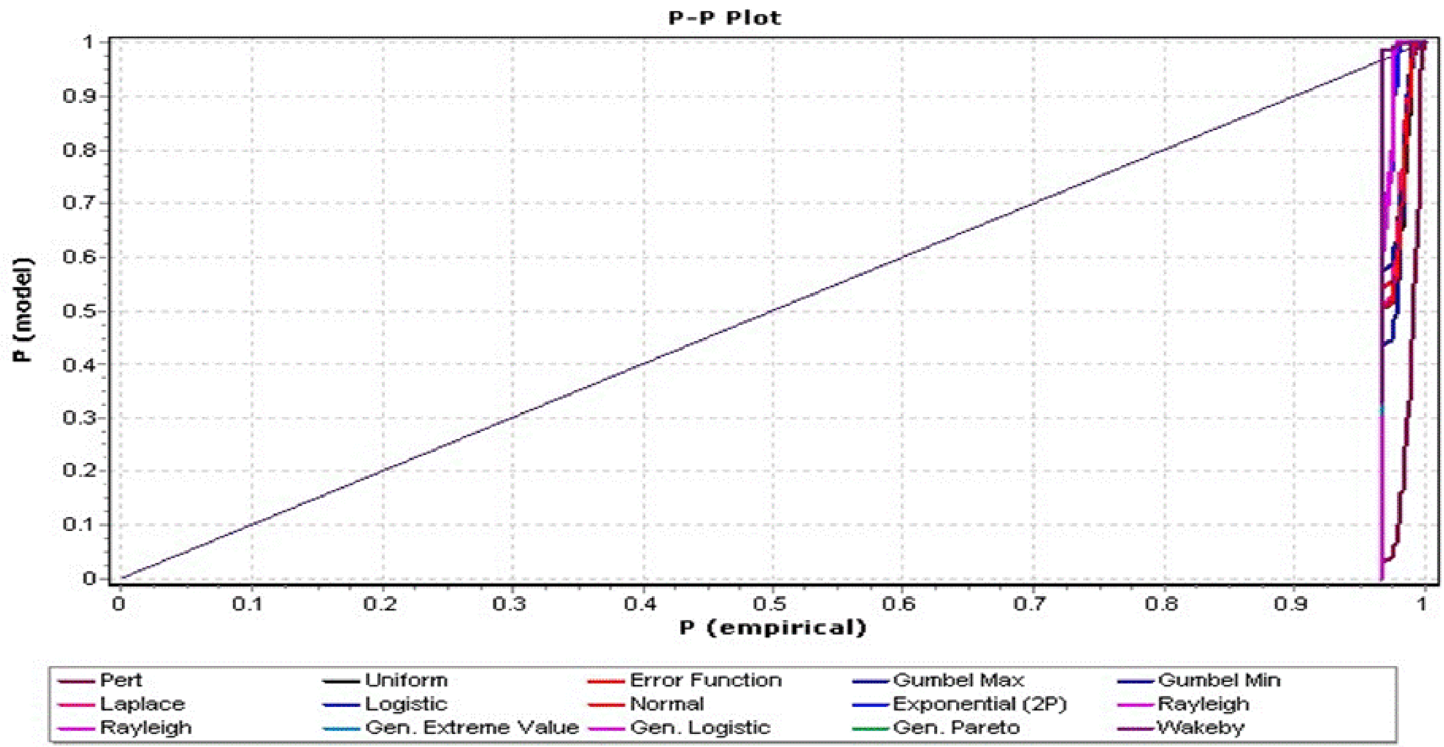

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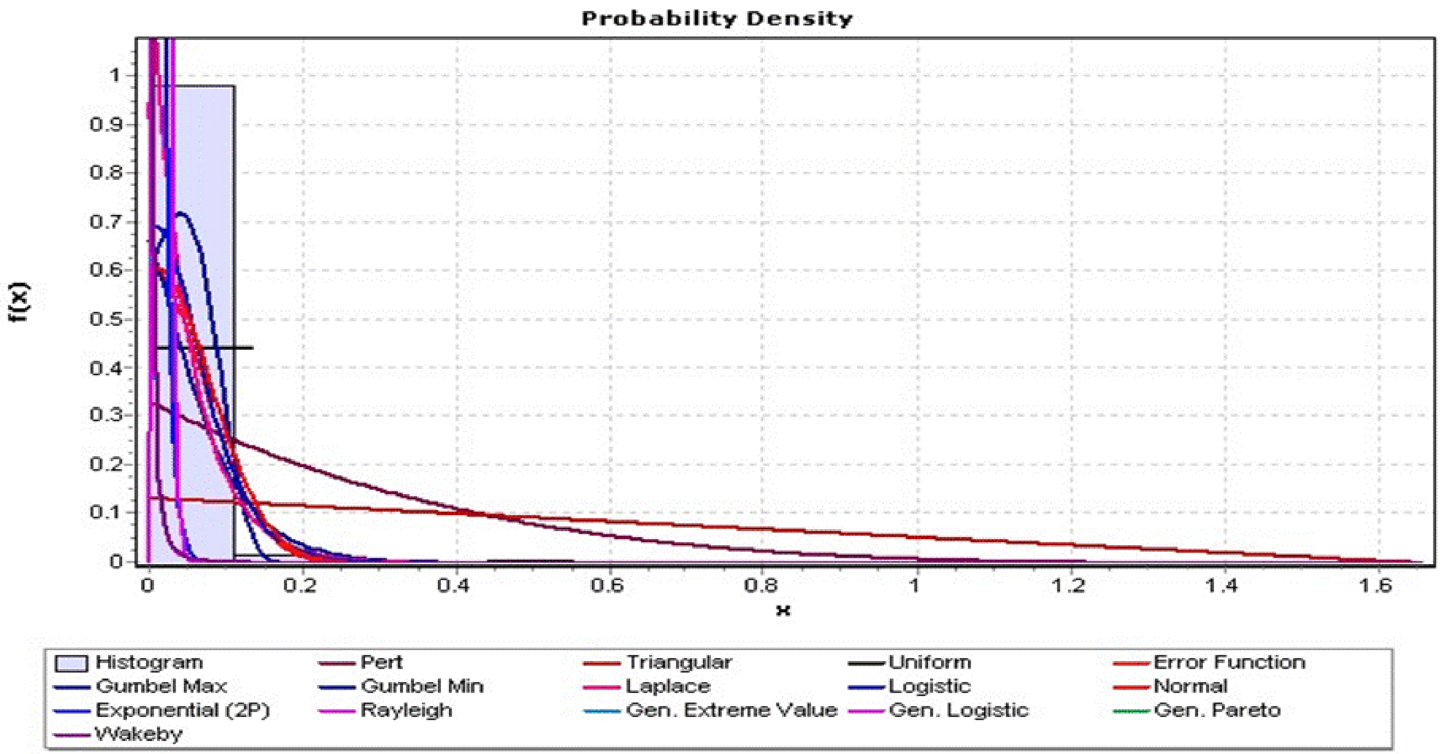
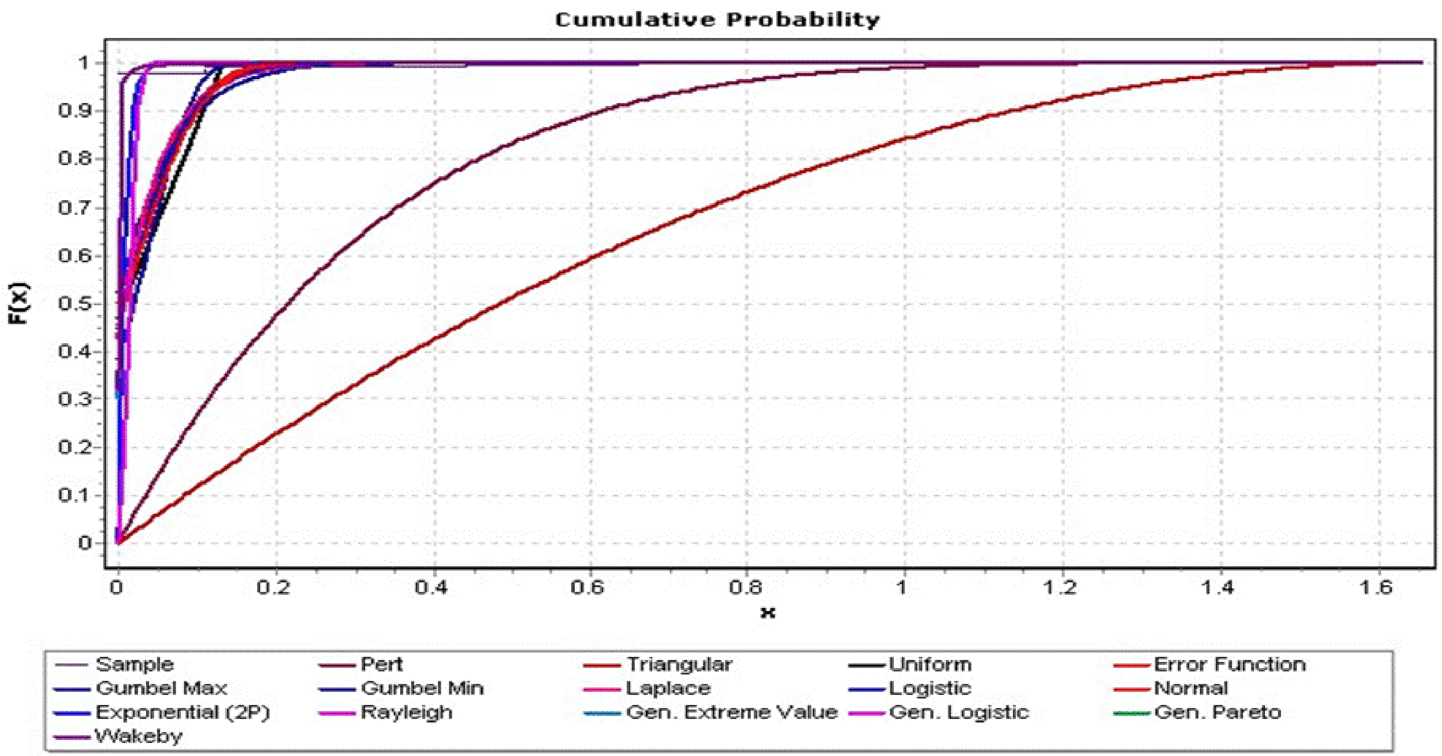


Fig. A.41 - Historic frequency distribution of averaged precipitation for August.



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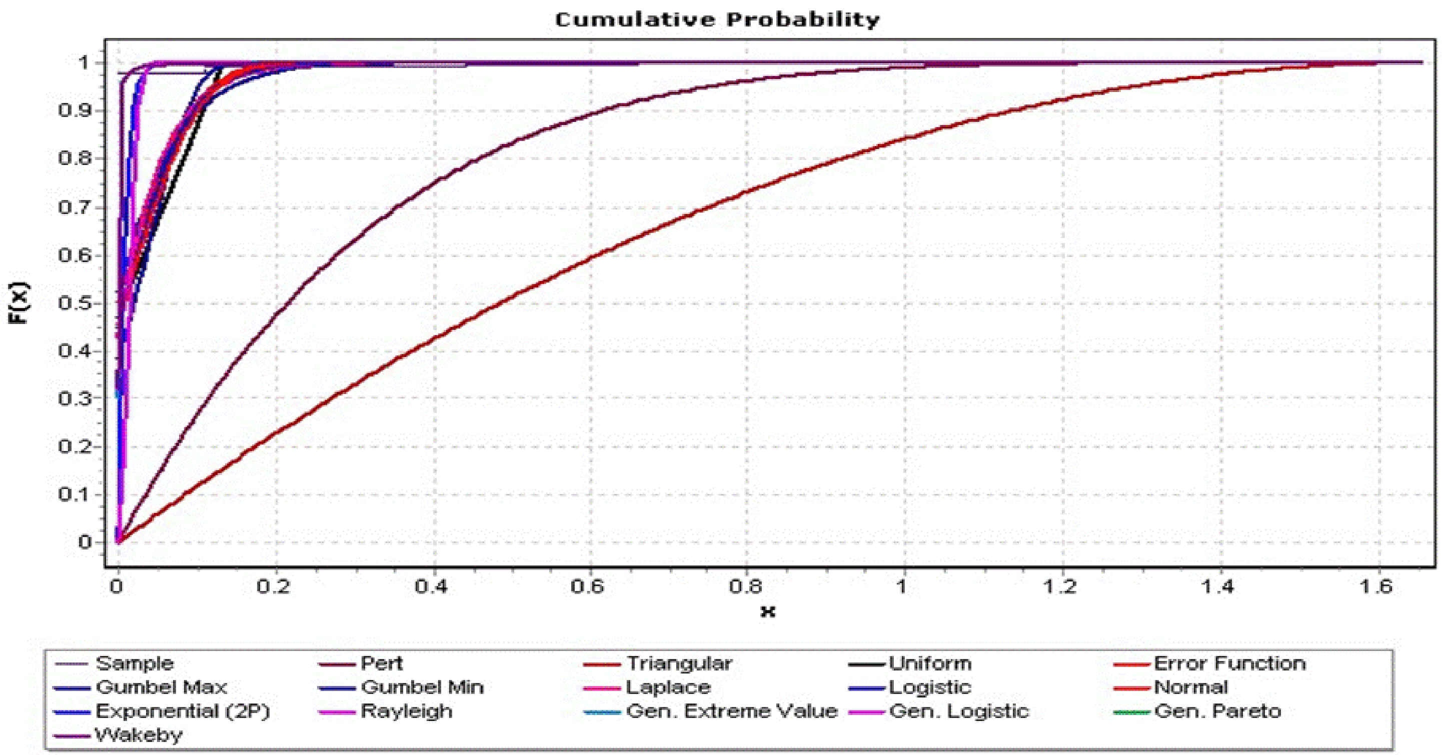

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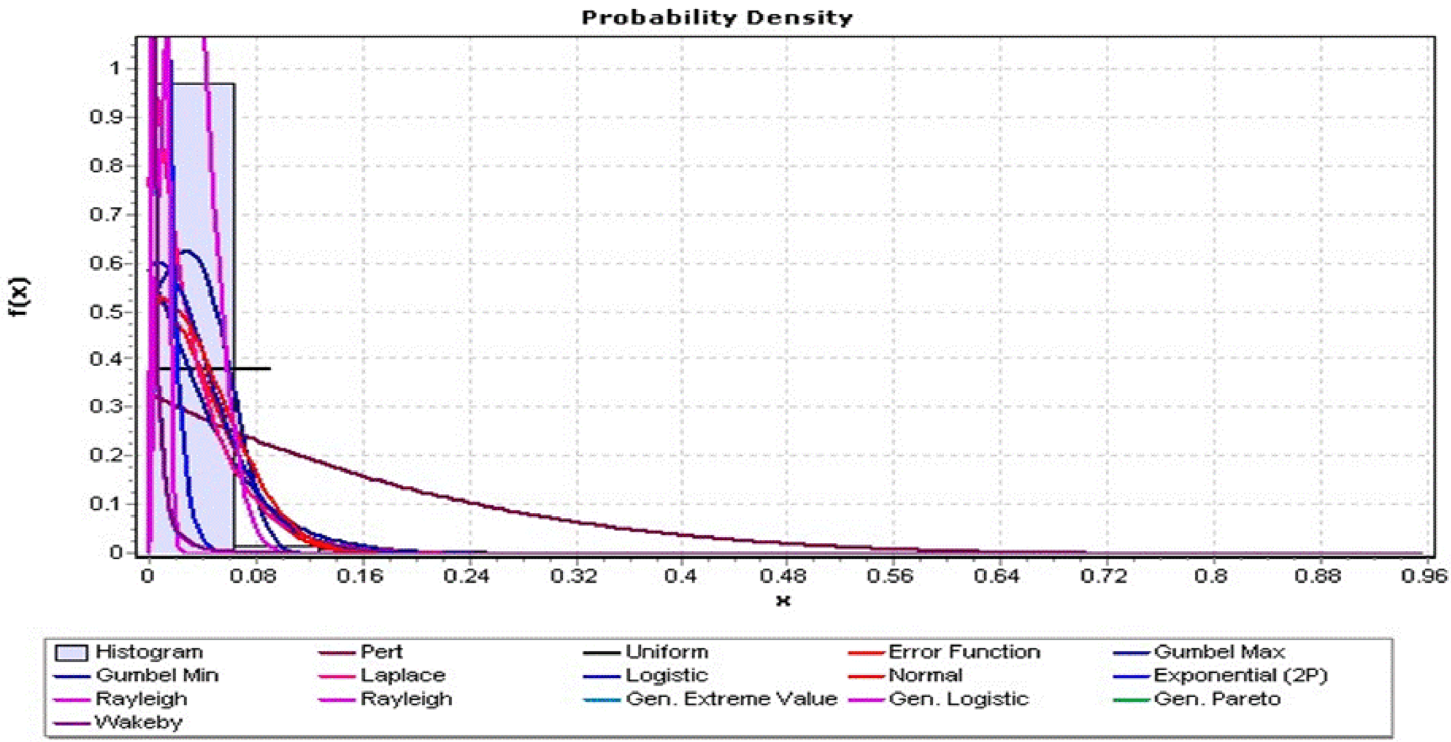
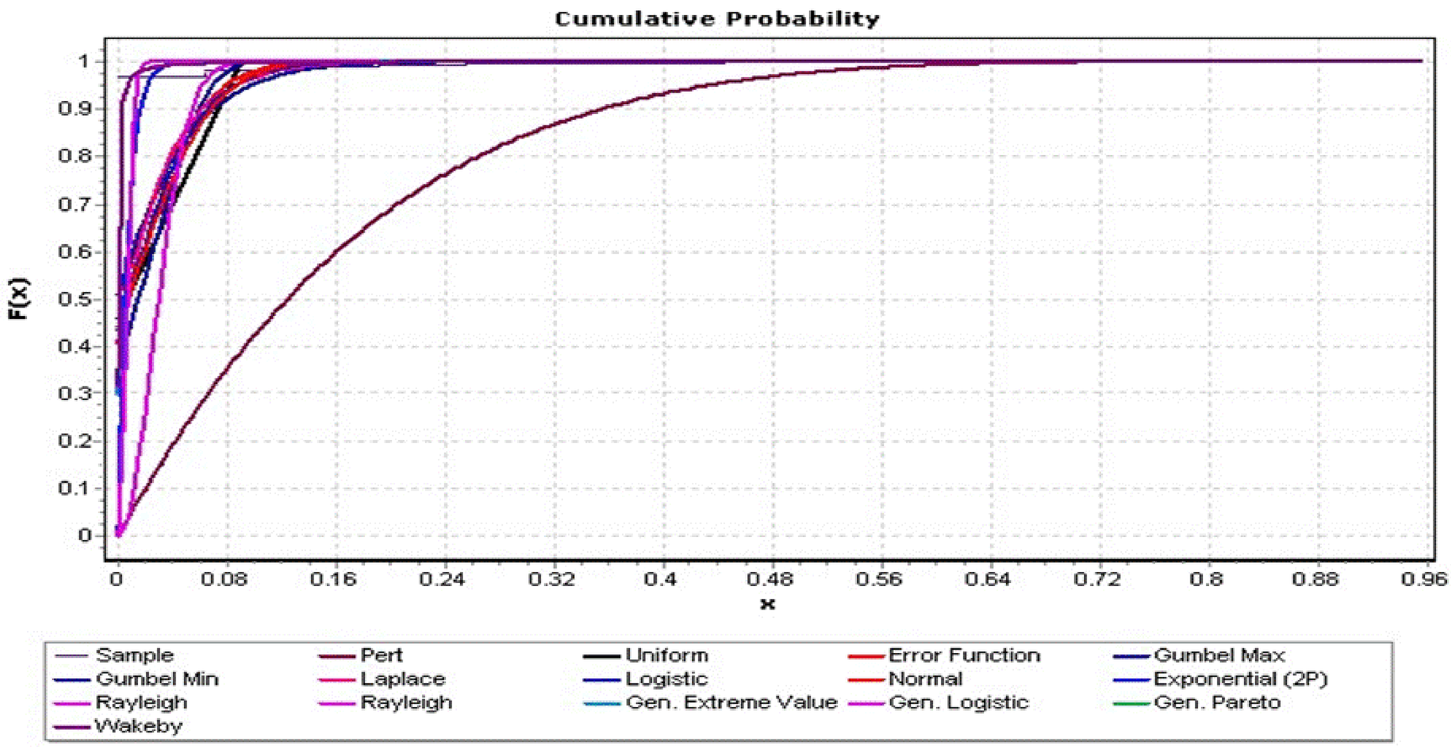


Fig. A.42 - Historic frequency distribution of averaged precipitation for September.



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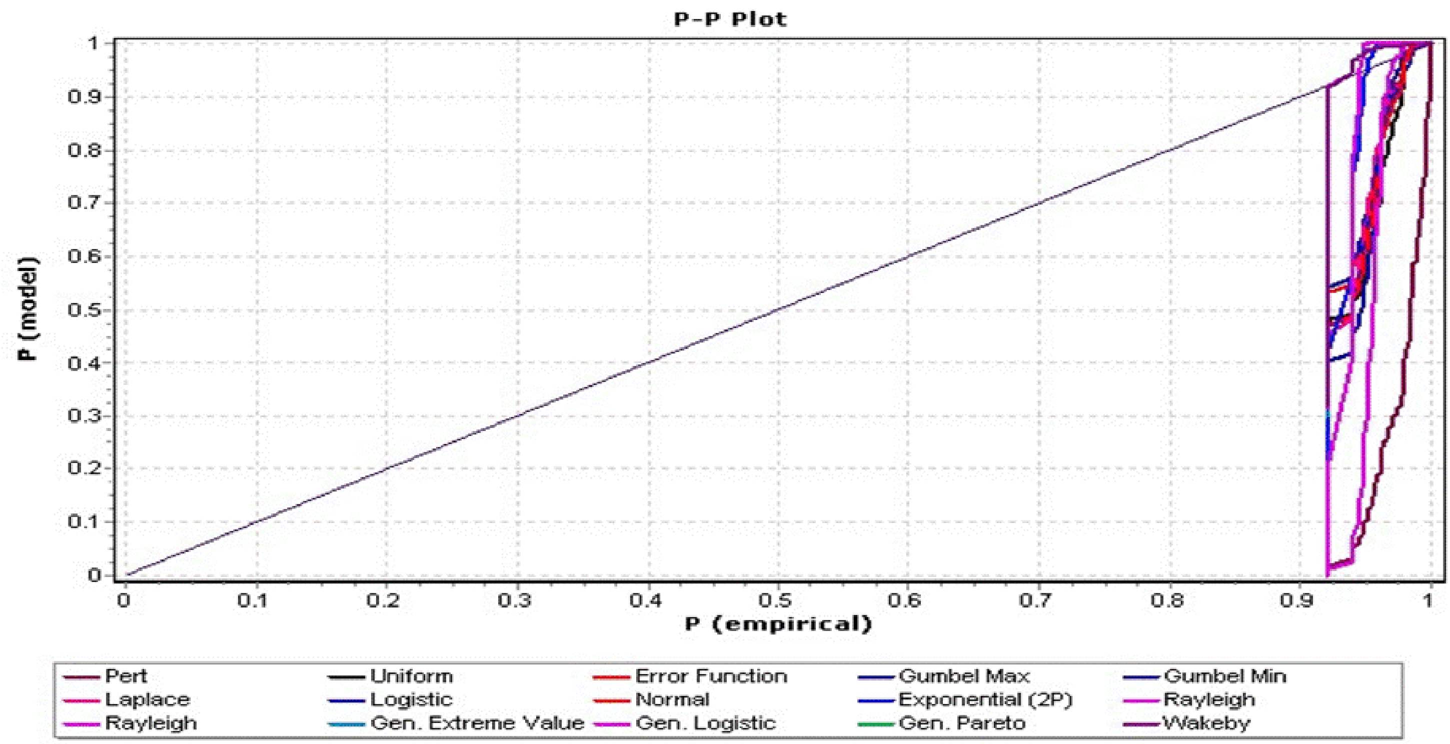

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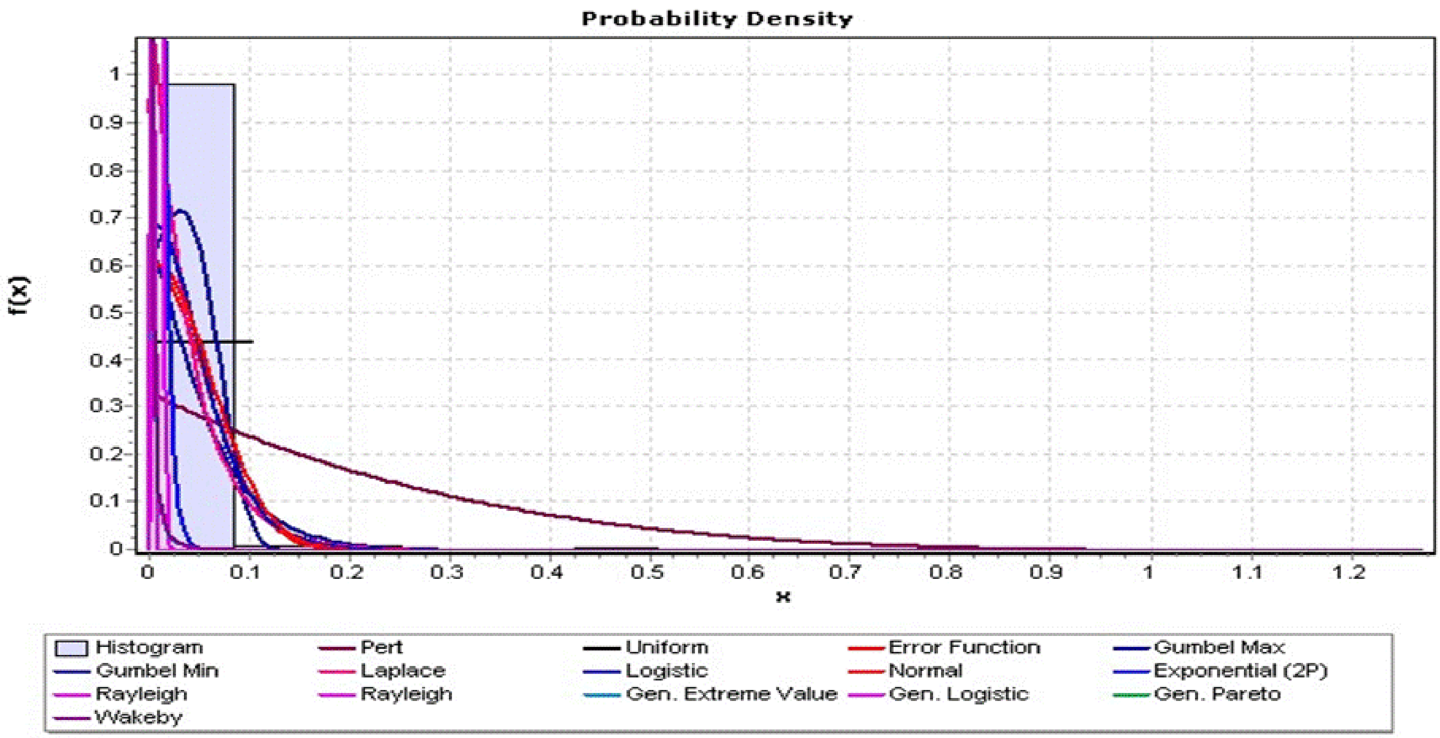
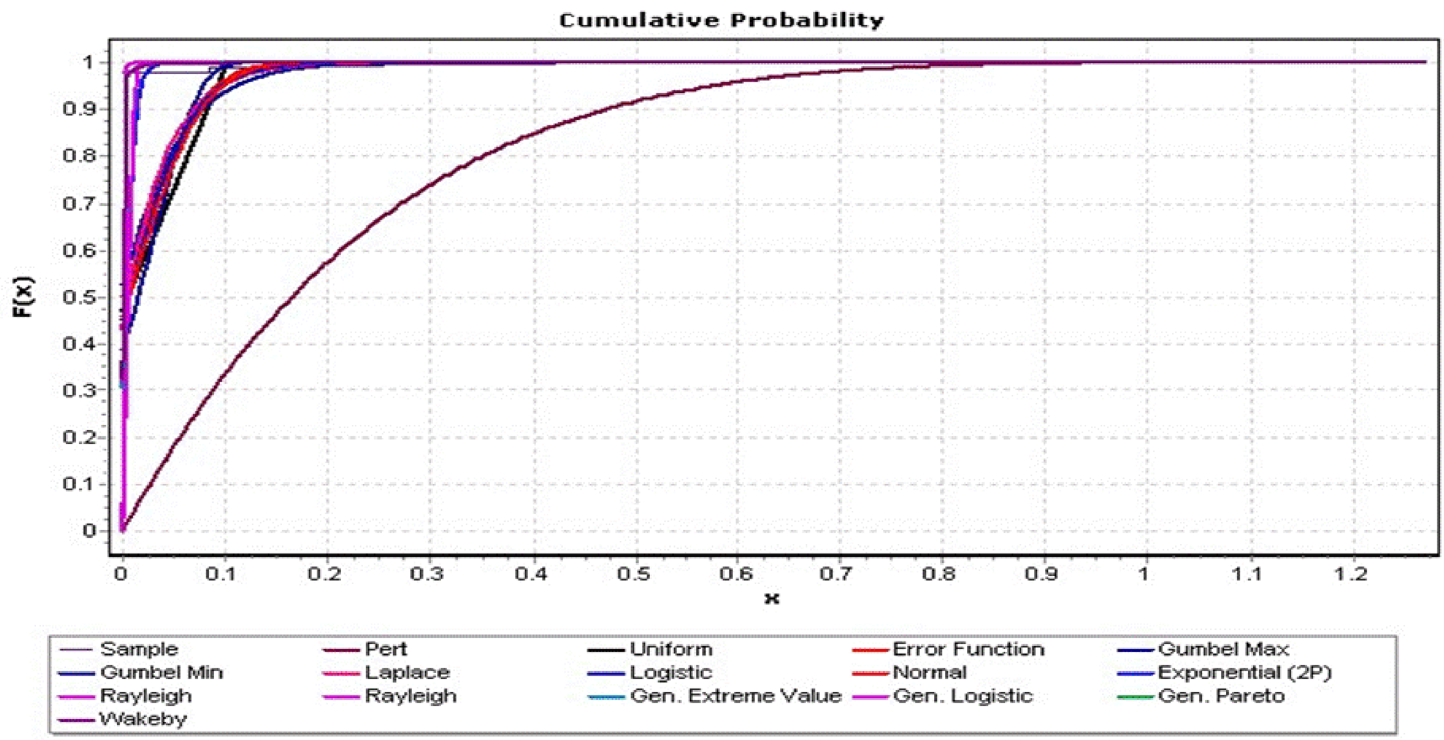


Fig. A.43 - Historic frequency distribution of averaged precipitation for October.



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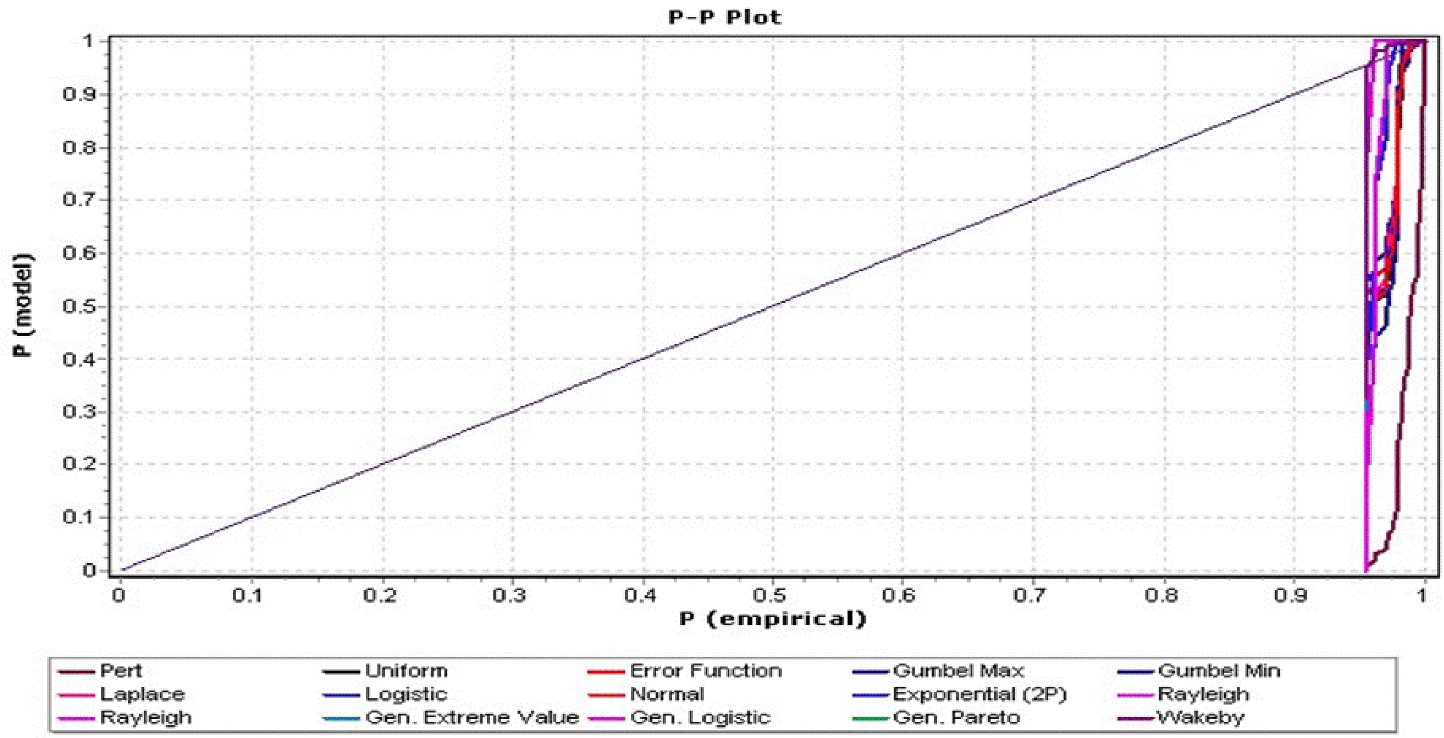


Fig. A.43 - (Continued).

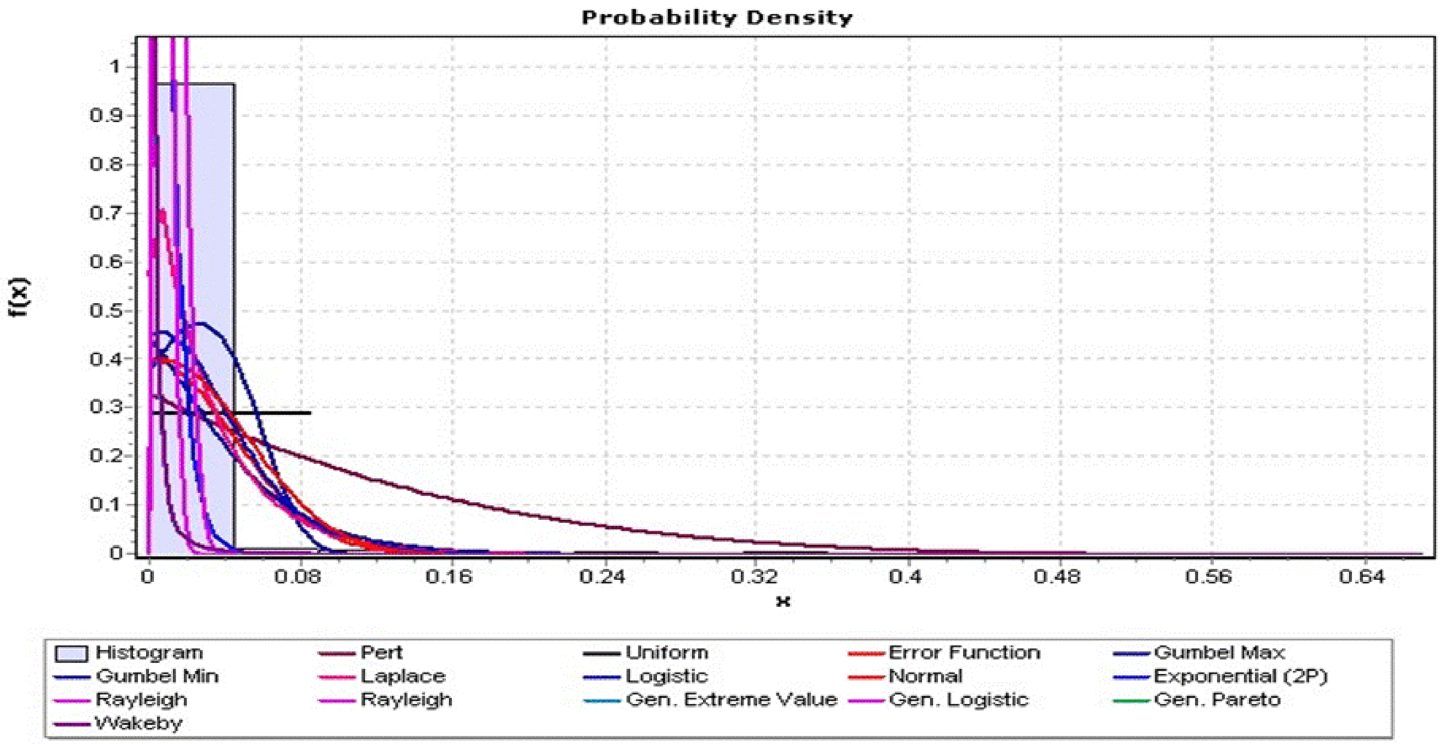
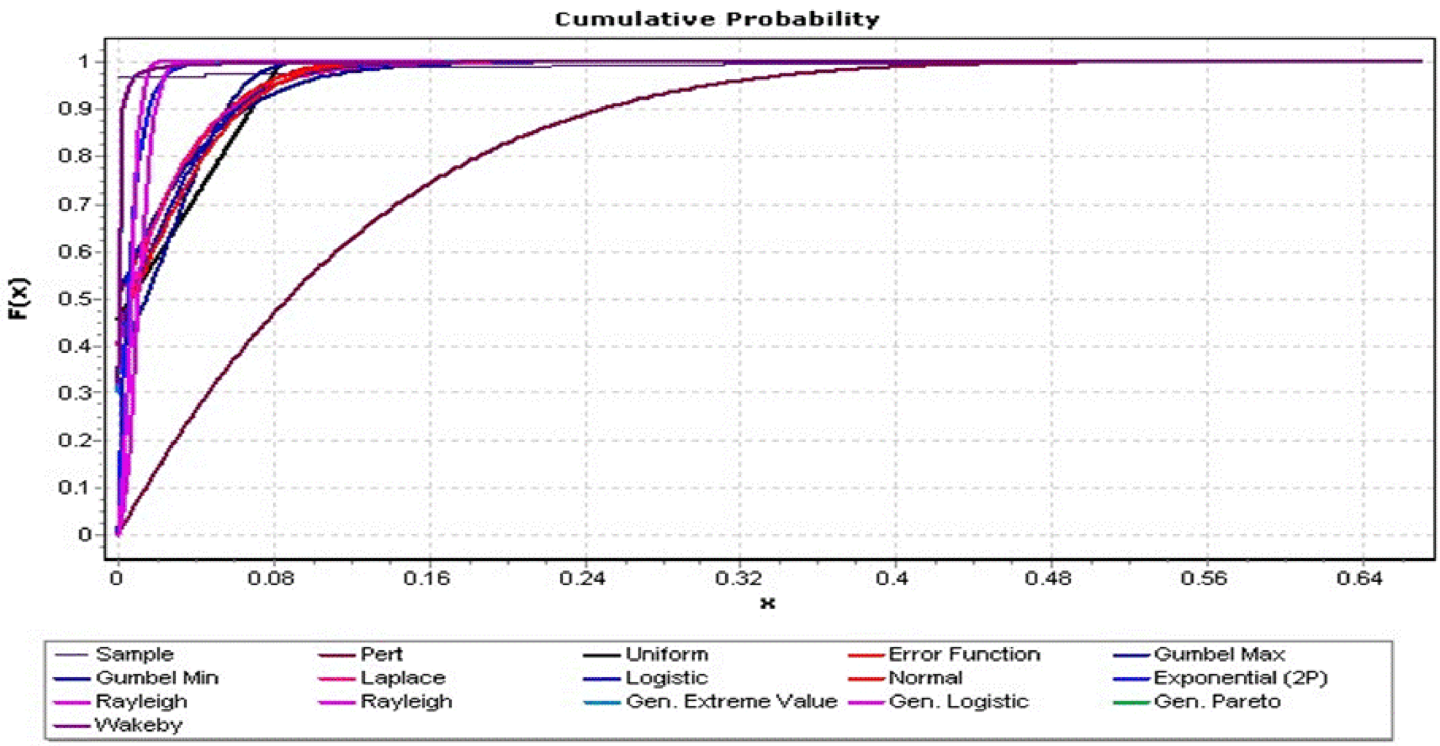


Fig. A.44 - Historic frequency distribution of averaged precipitation for November.



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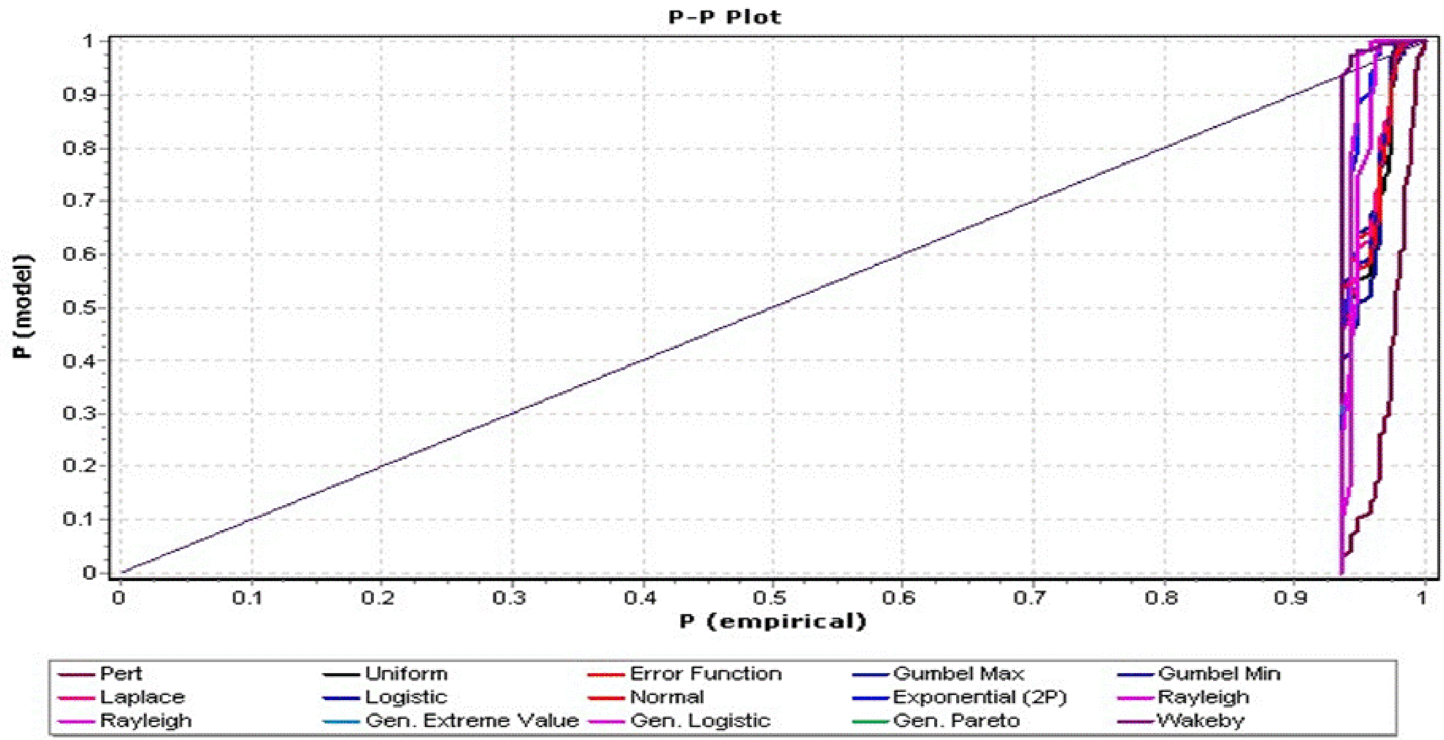


Fig. A.44 - (Continued).

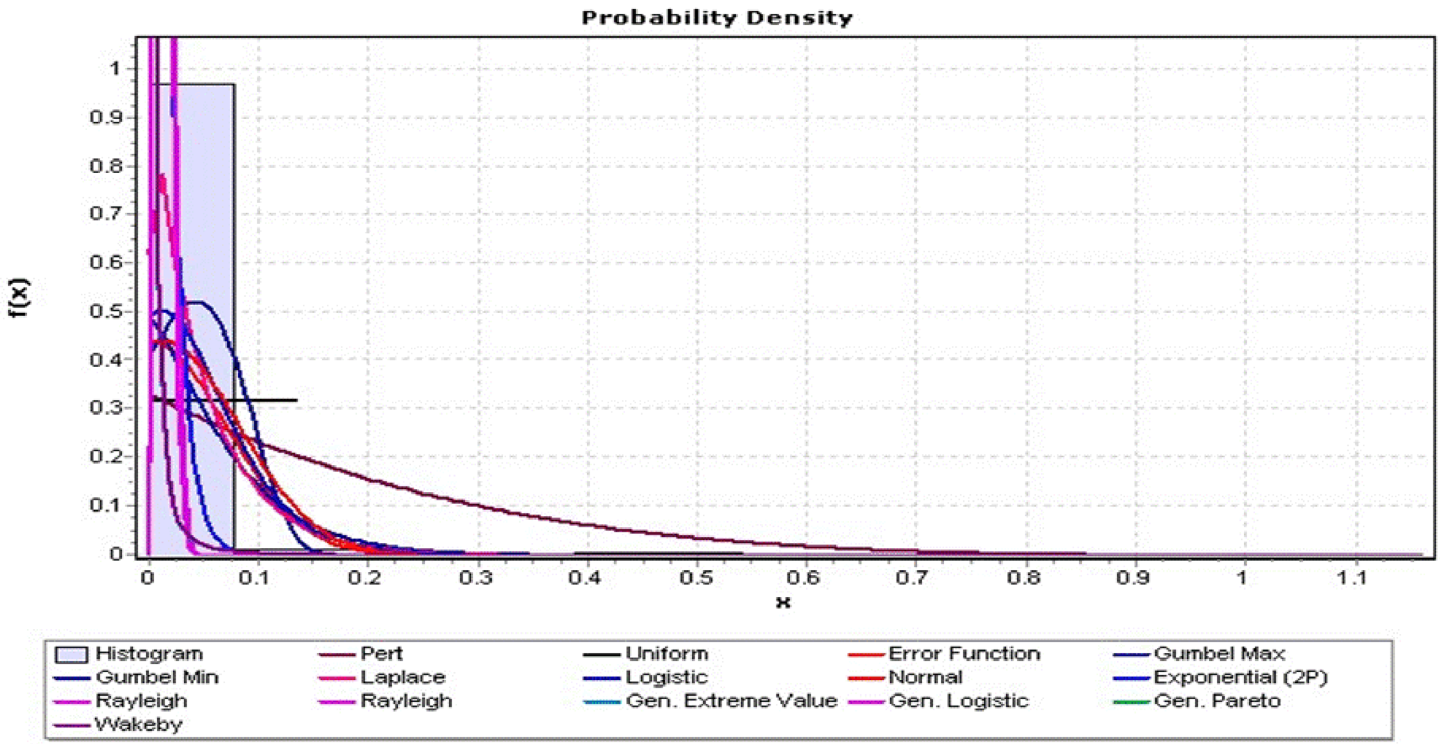


Fig. A.45 - Historic frequency distribution of averaged precipitation for December.

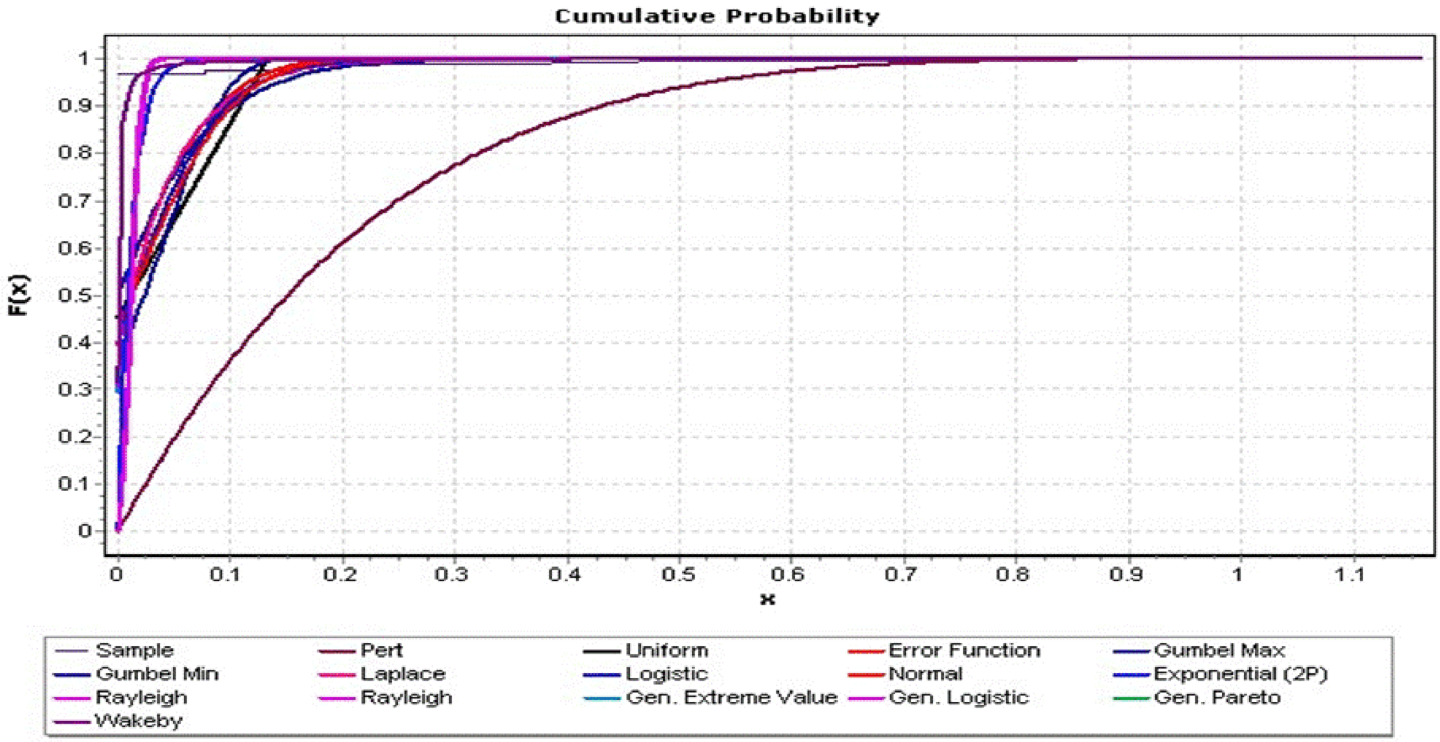
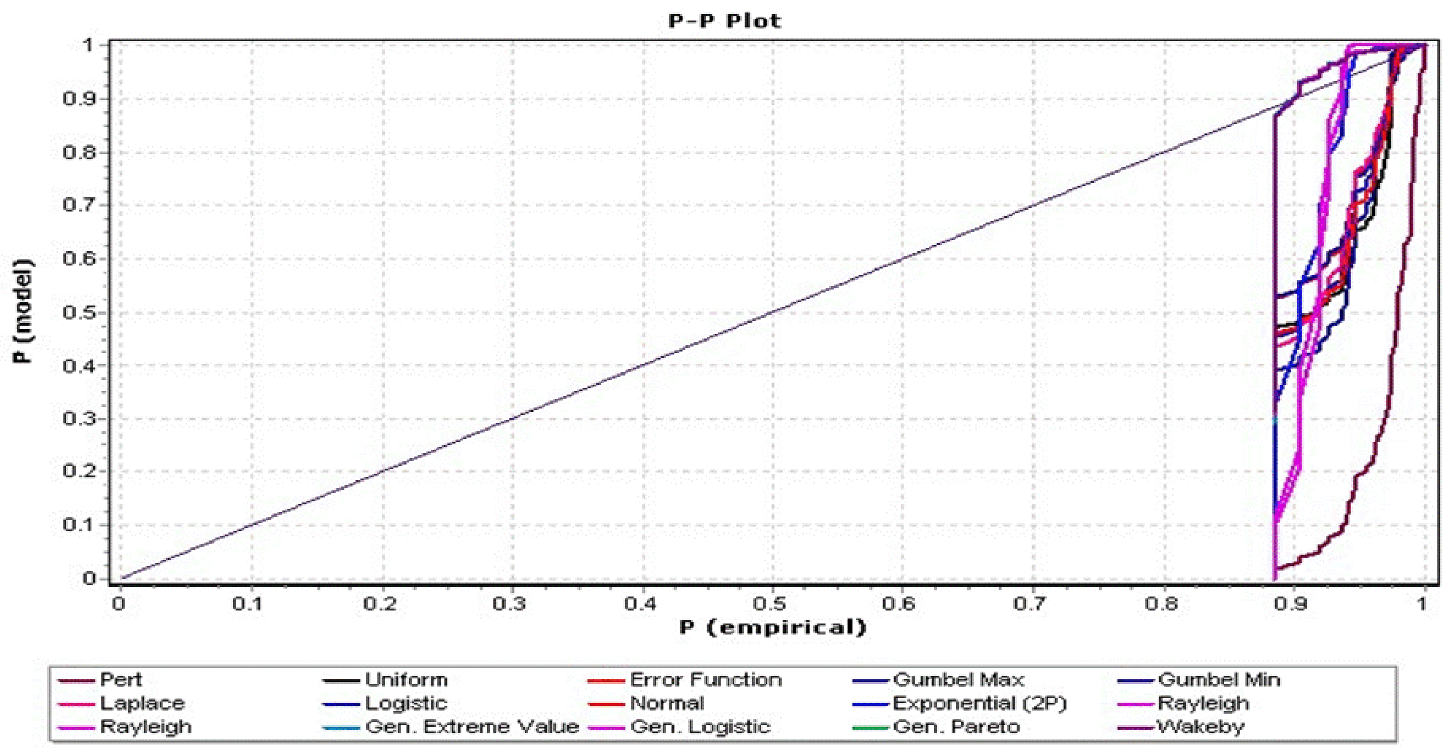


Fig. A.45 - (Continued).



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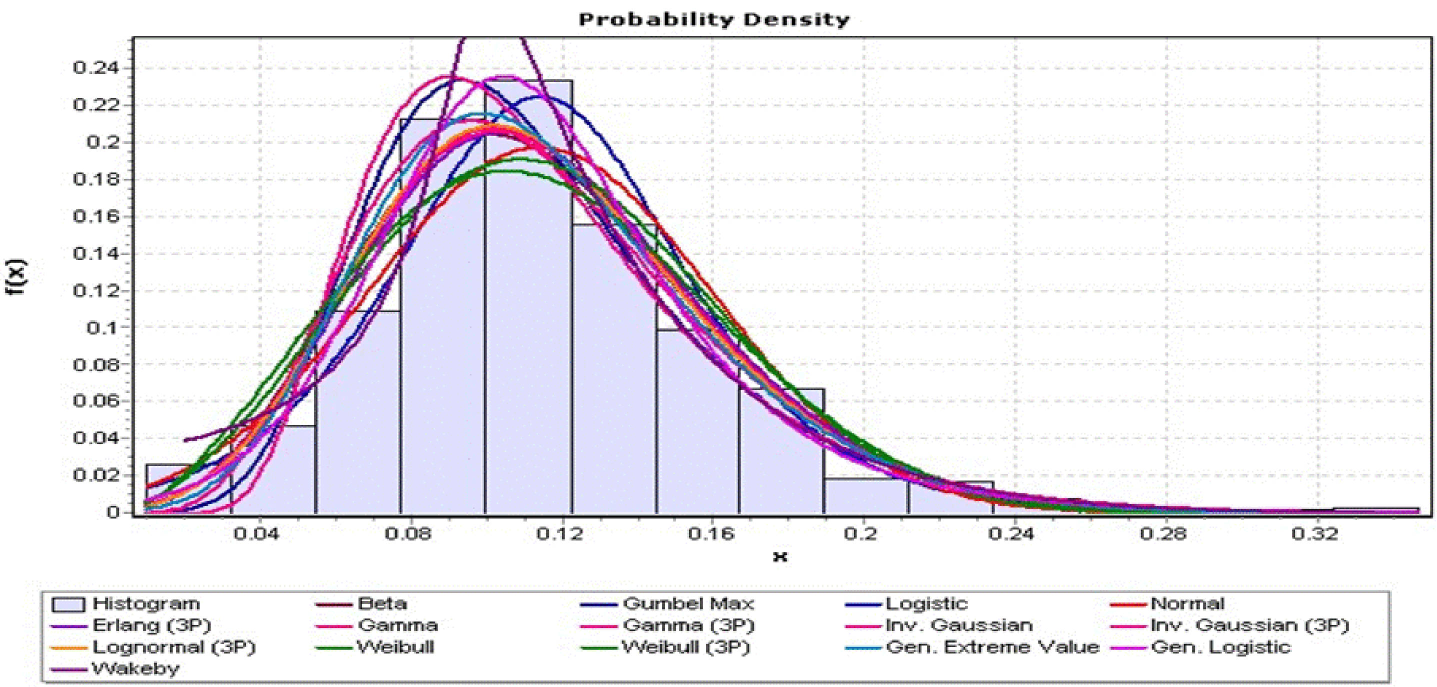


Fig. A.46 - Historic frequency distribution of averaged Eto for January.

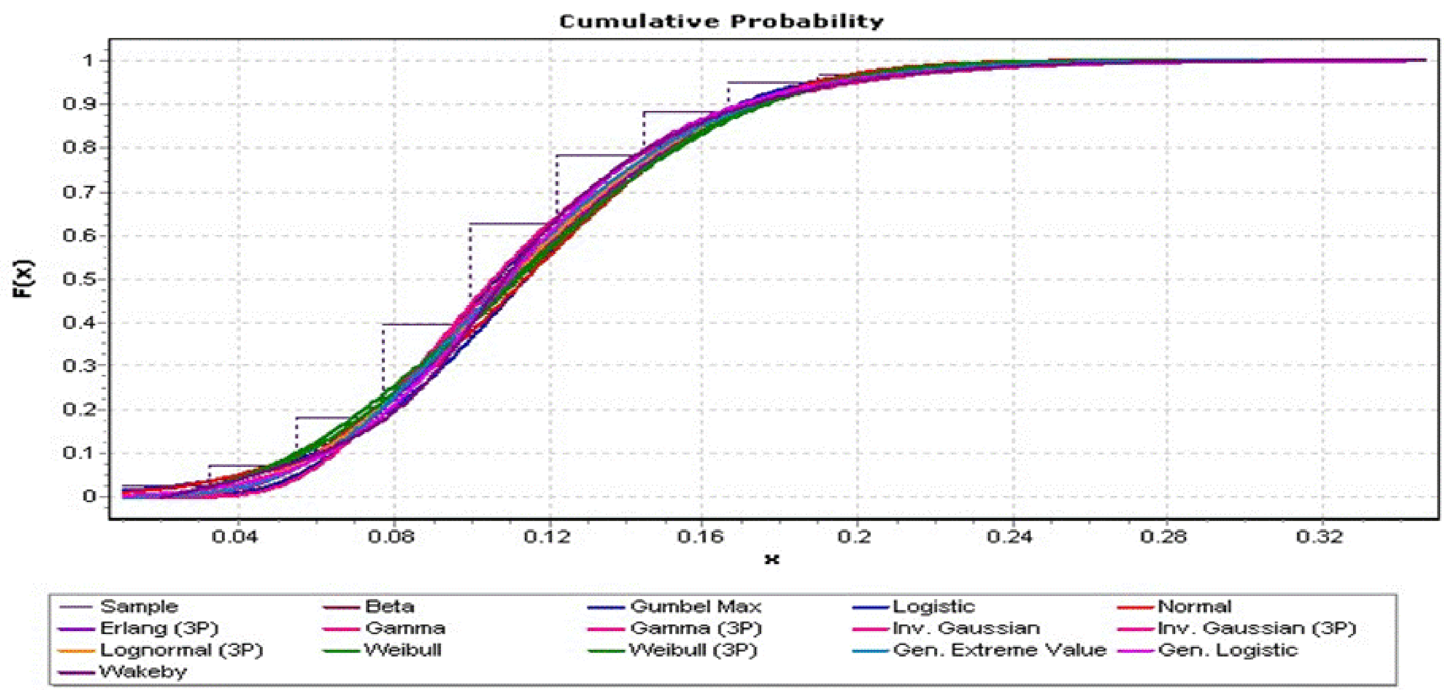


Fig. A.46 - (Continued).

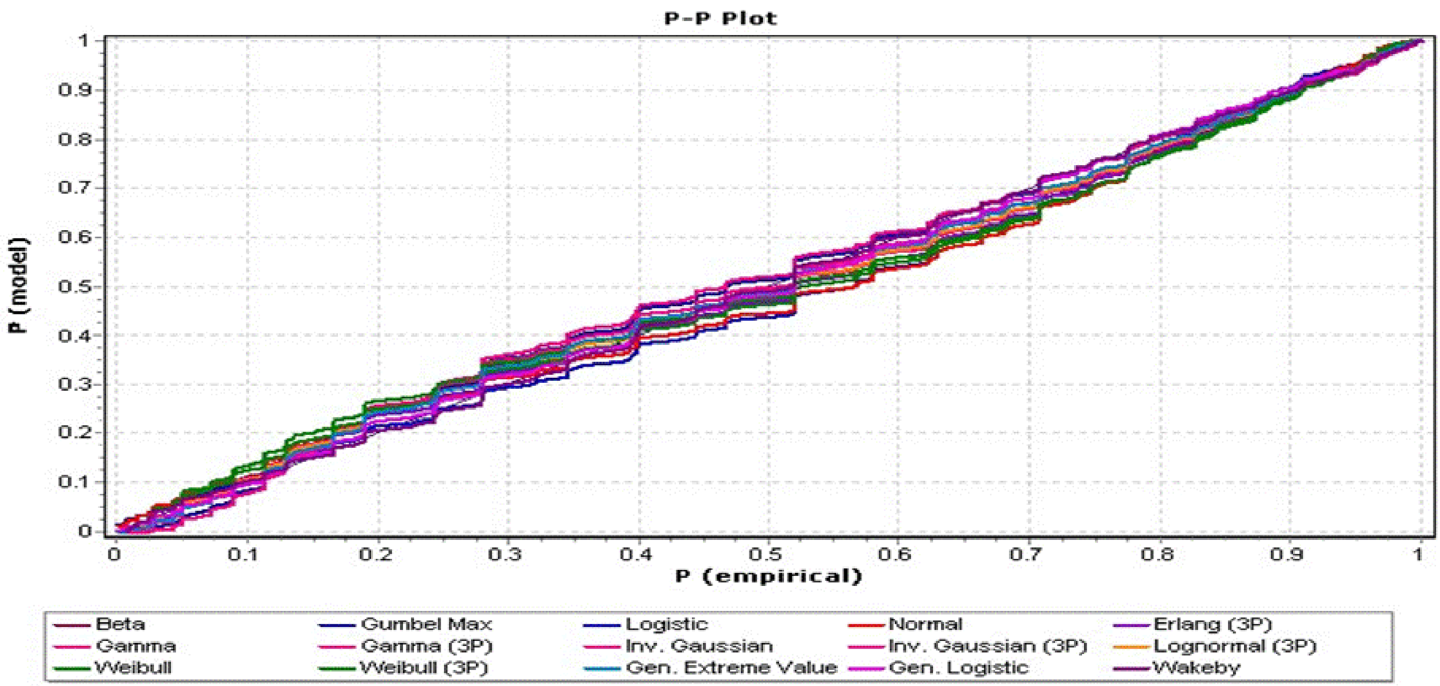


Fig. A.46 - (Continued).

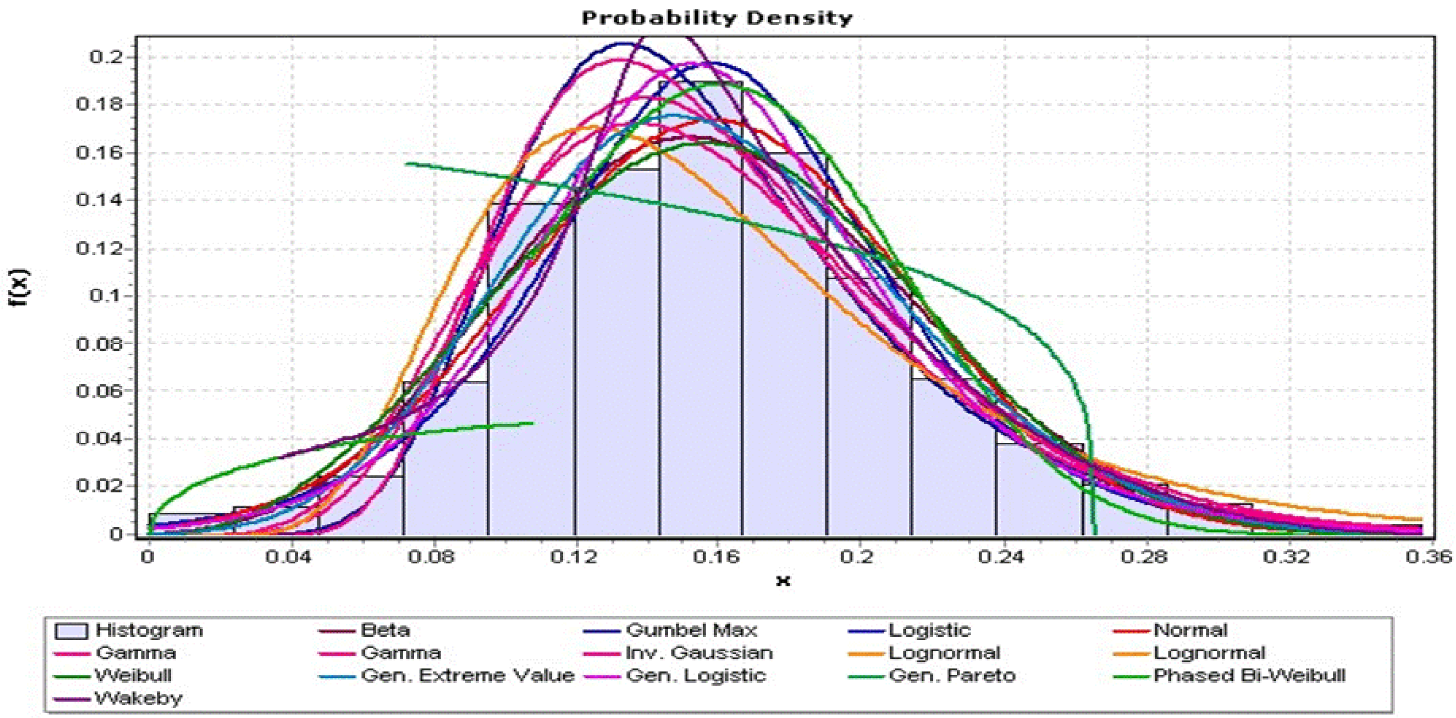


Fig. A.47 - Historic frequency distribution of averaged Eto for February.

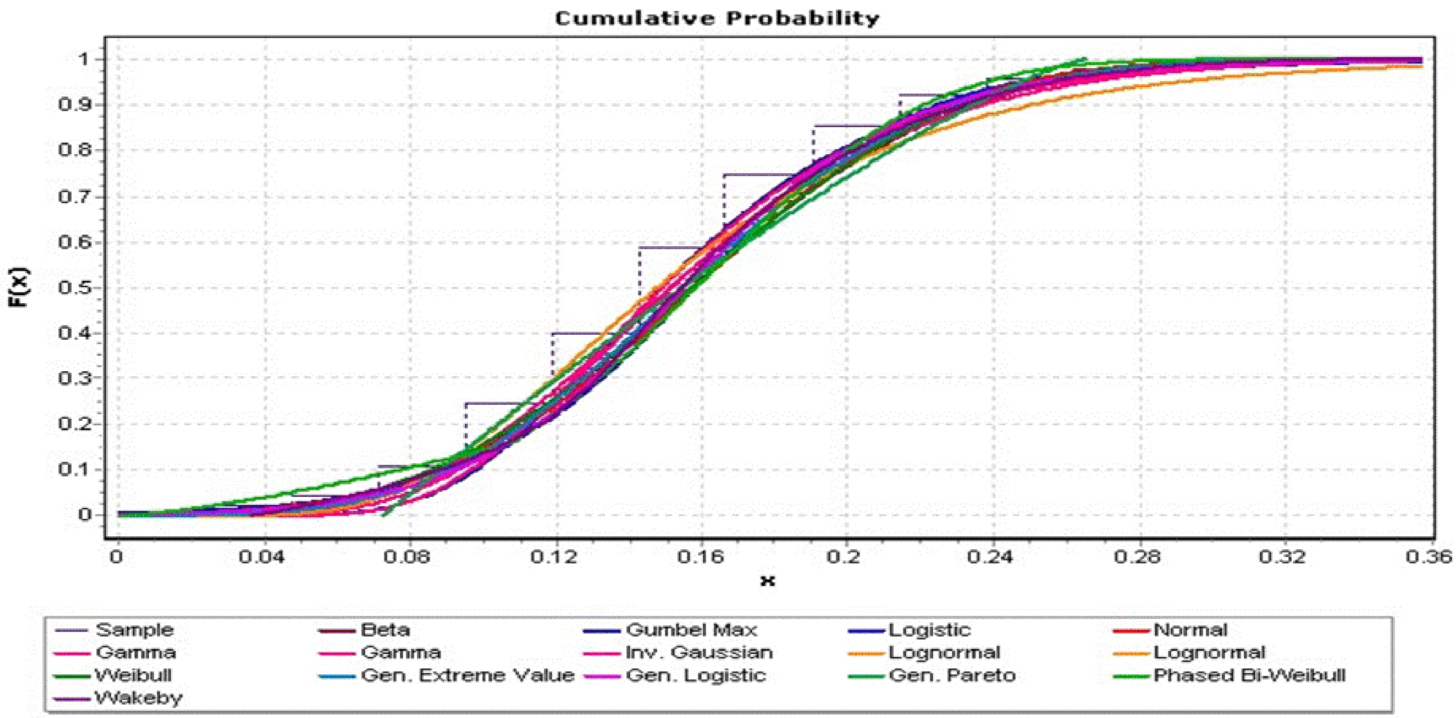


Fig. A.47 - (Continued).

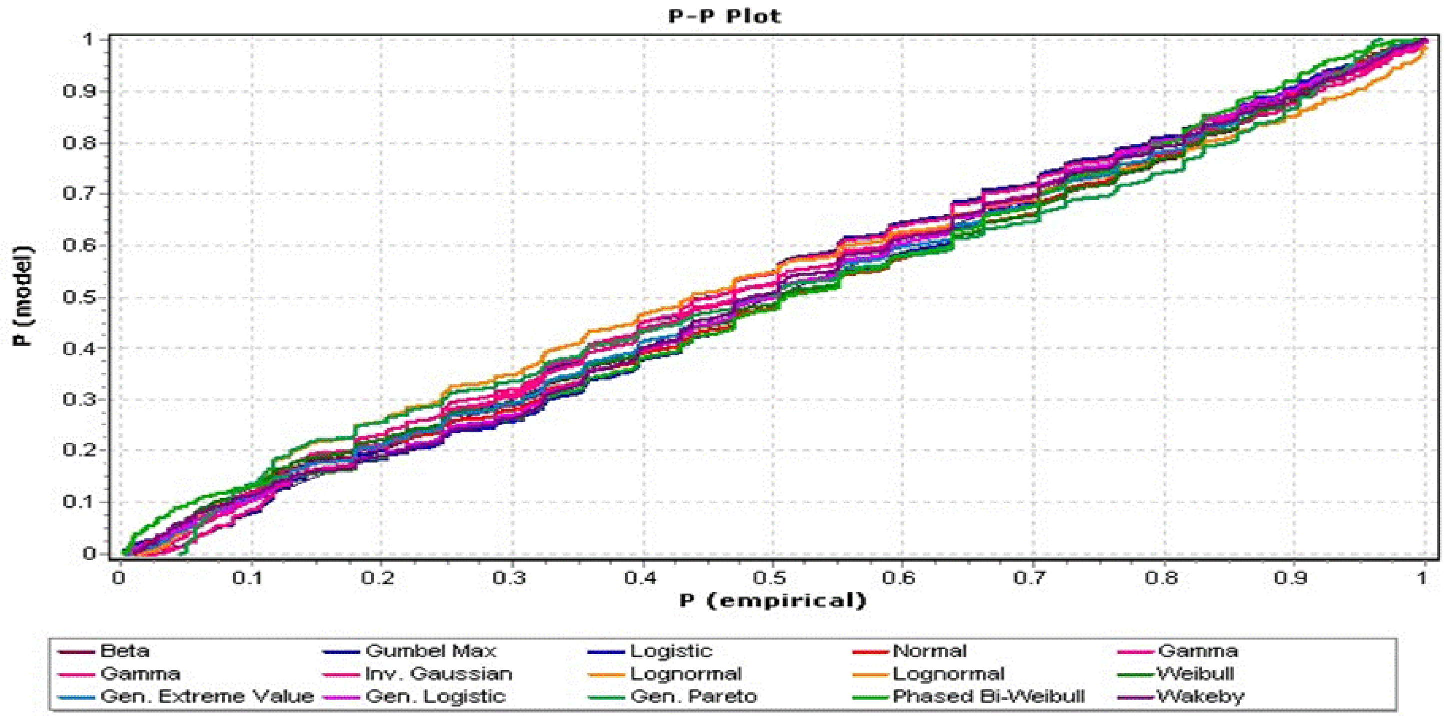


Fig. A.47 - (Continued).

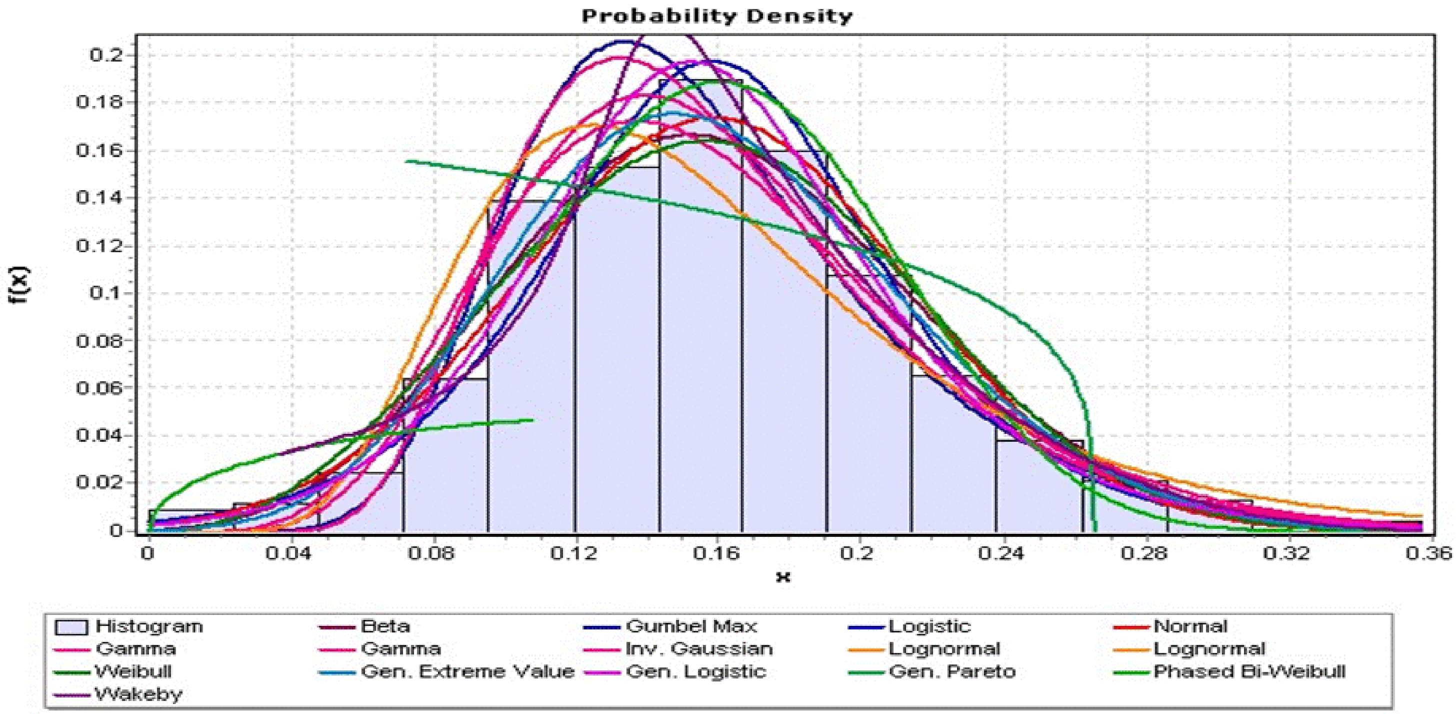


Fig. A.48 - Historic frequency distribution of averaged Eto for March.

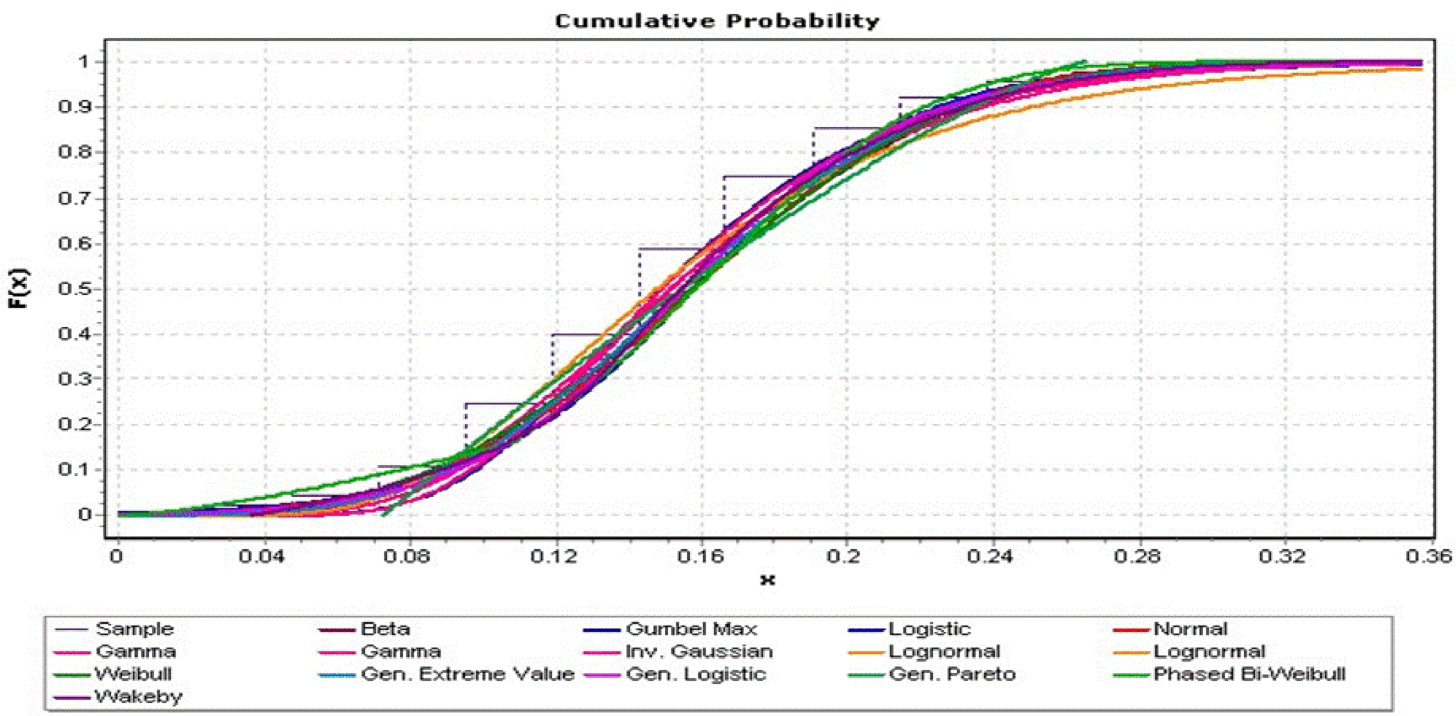


Fig. A.48 - (Continued).

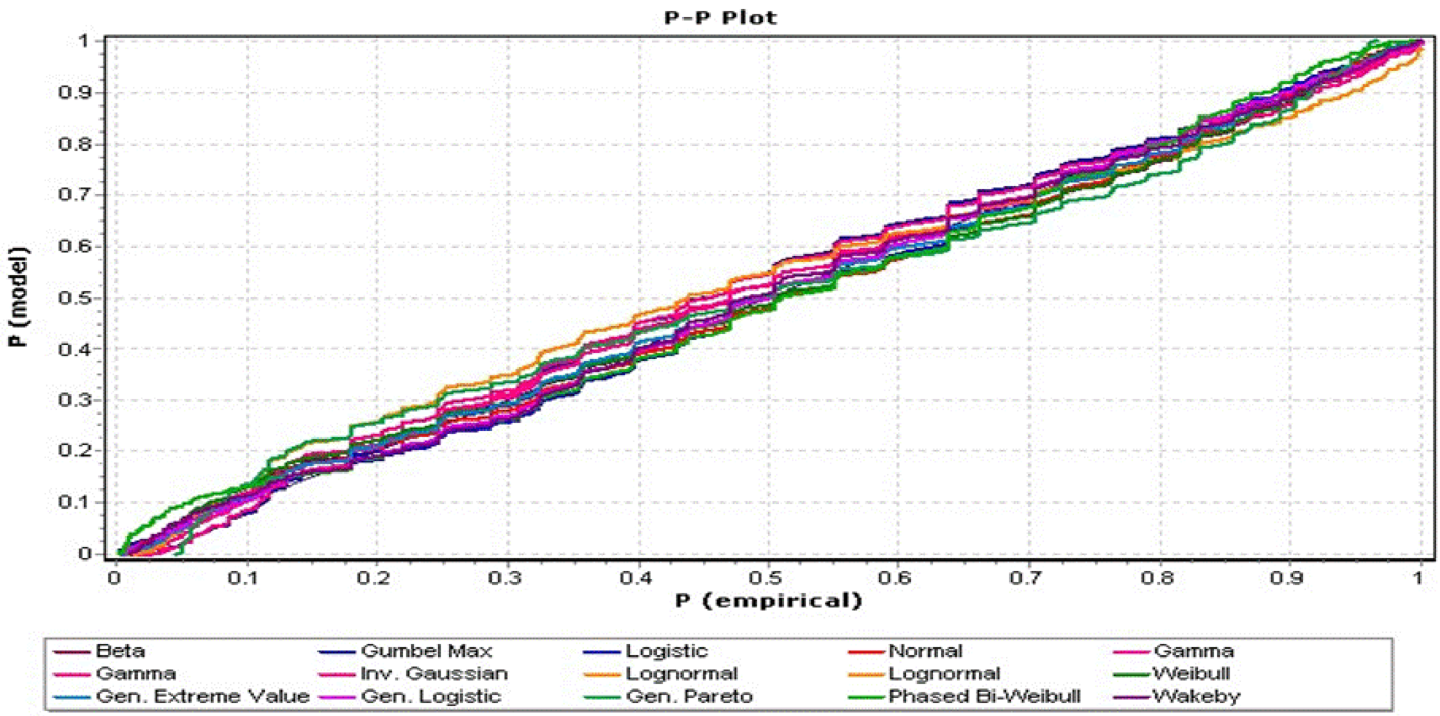


Fig. A.48 - (Continued).

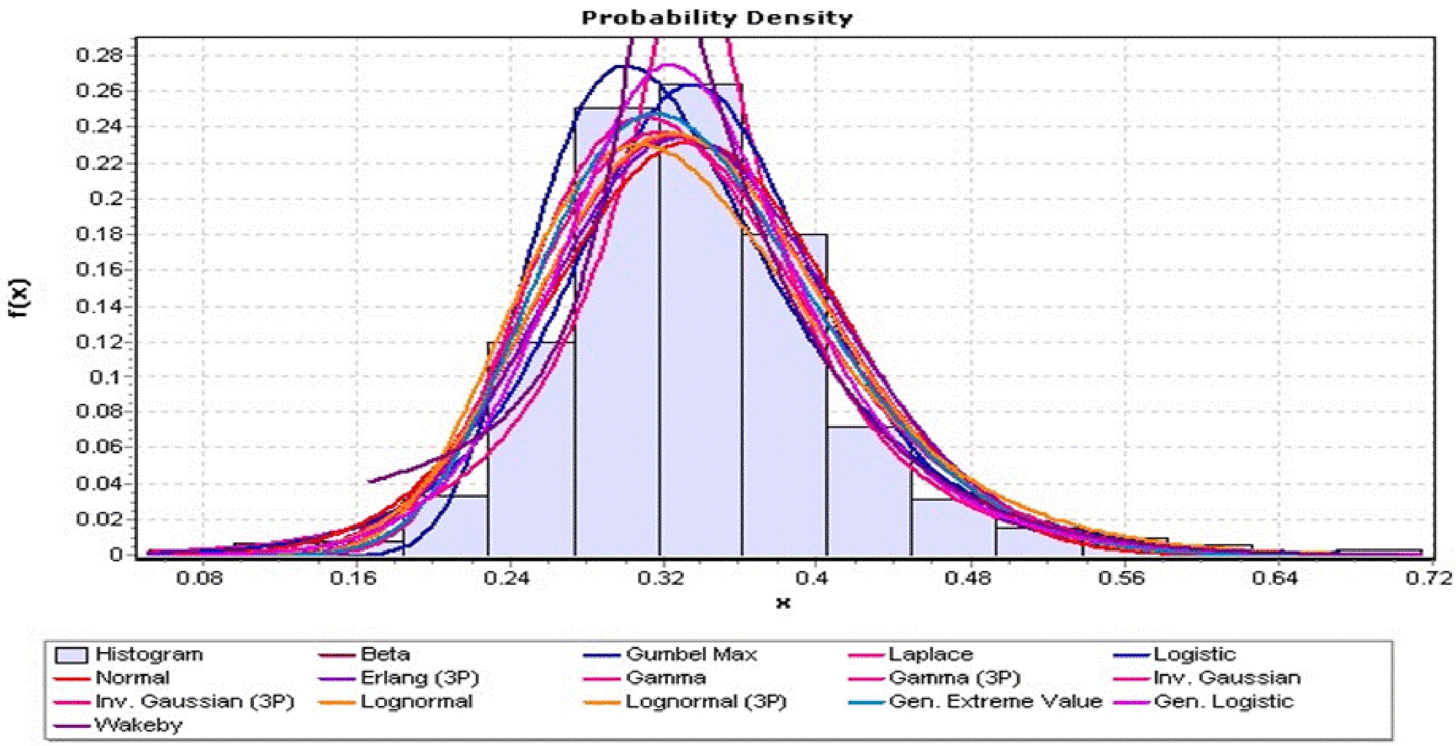


Fig. A.49 - Historic frequency distribution of averaged Eto for April.

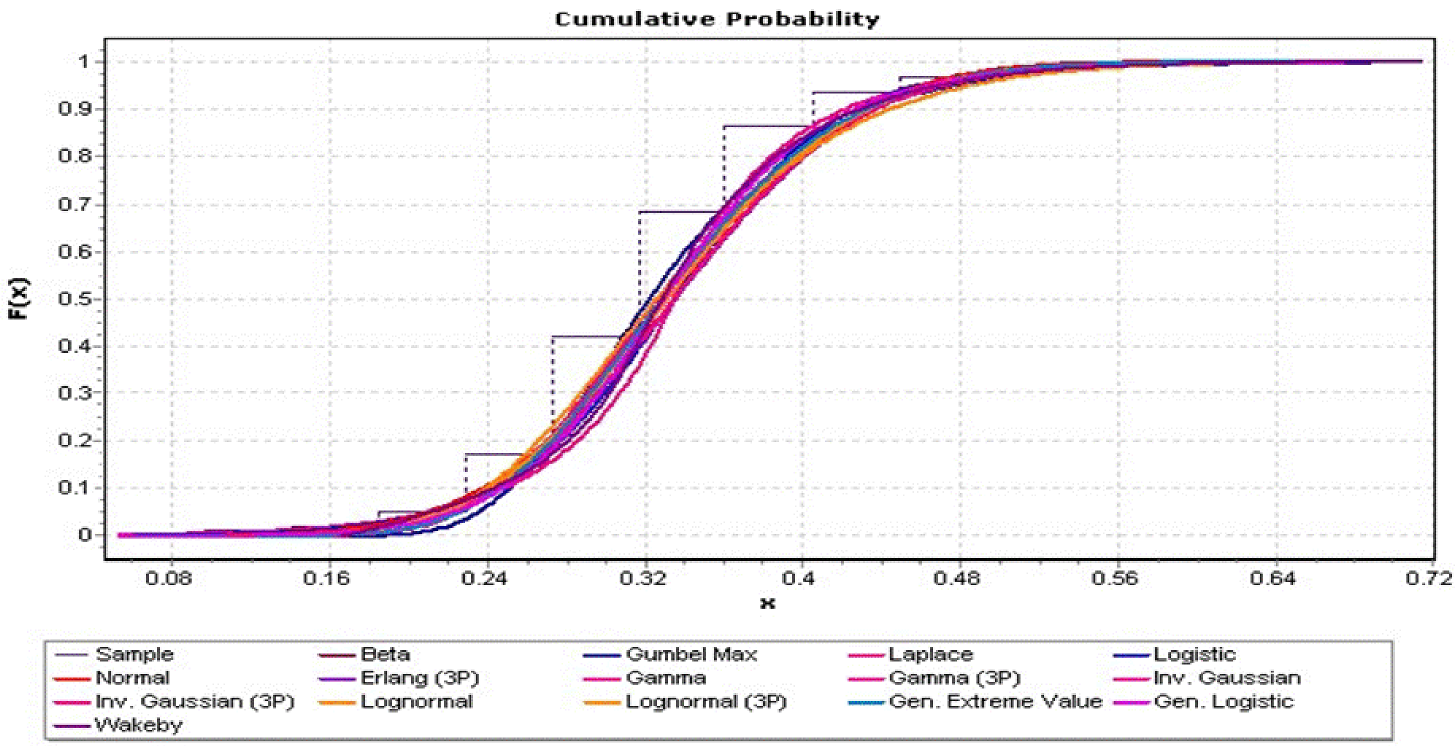


Fig. A.49 - (Continued).

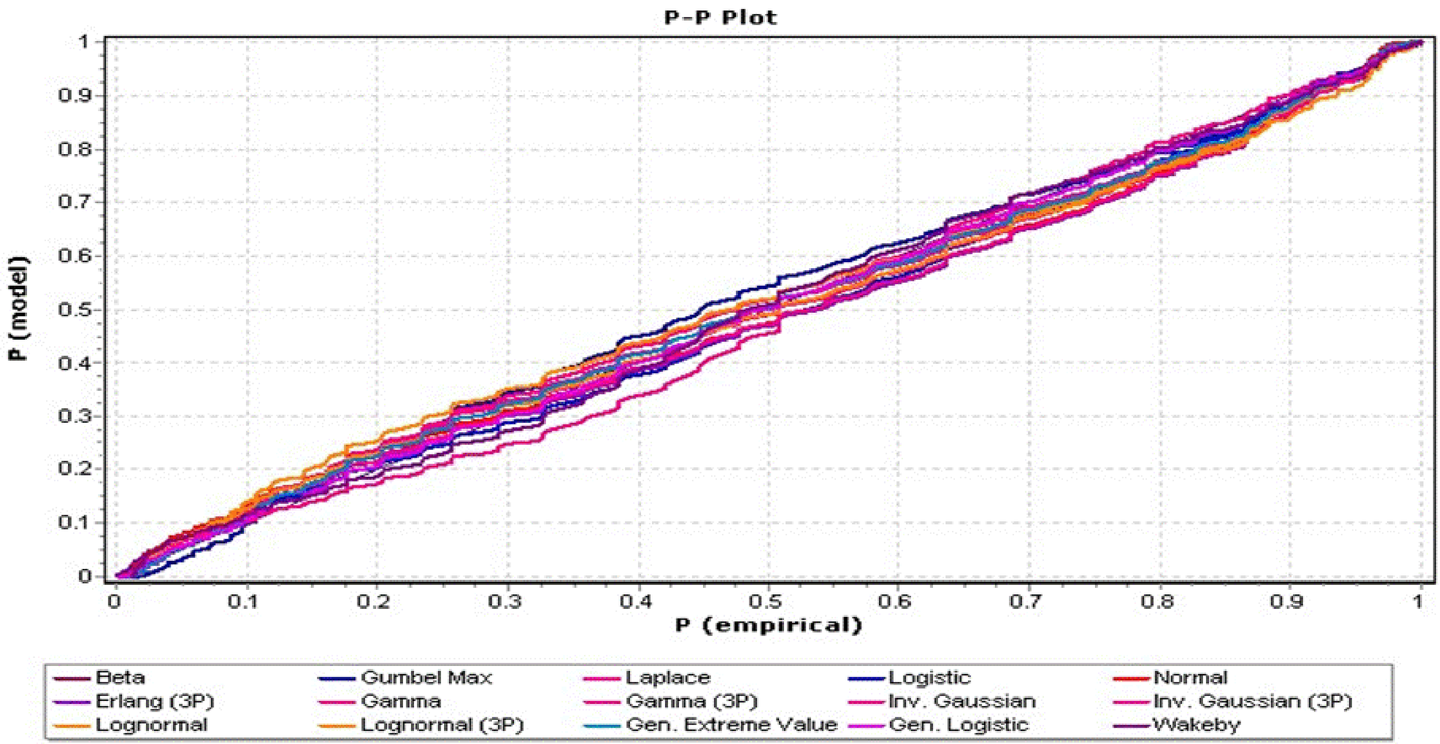


Fig. A.49 - (Continued).

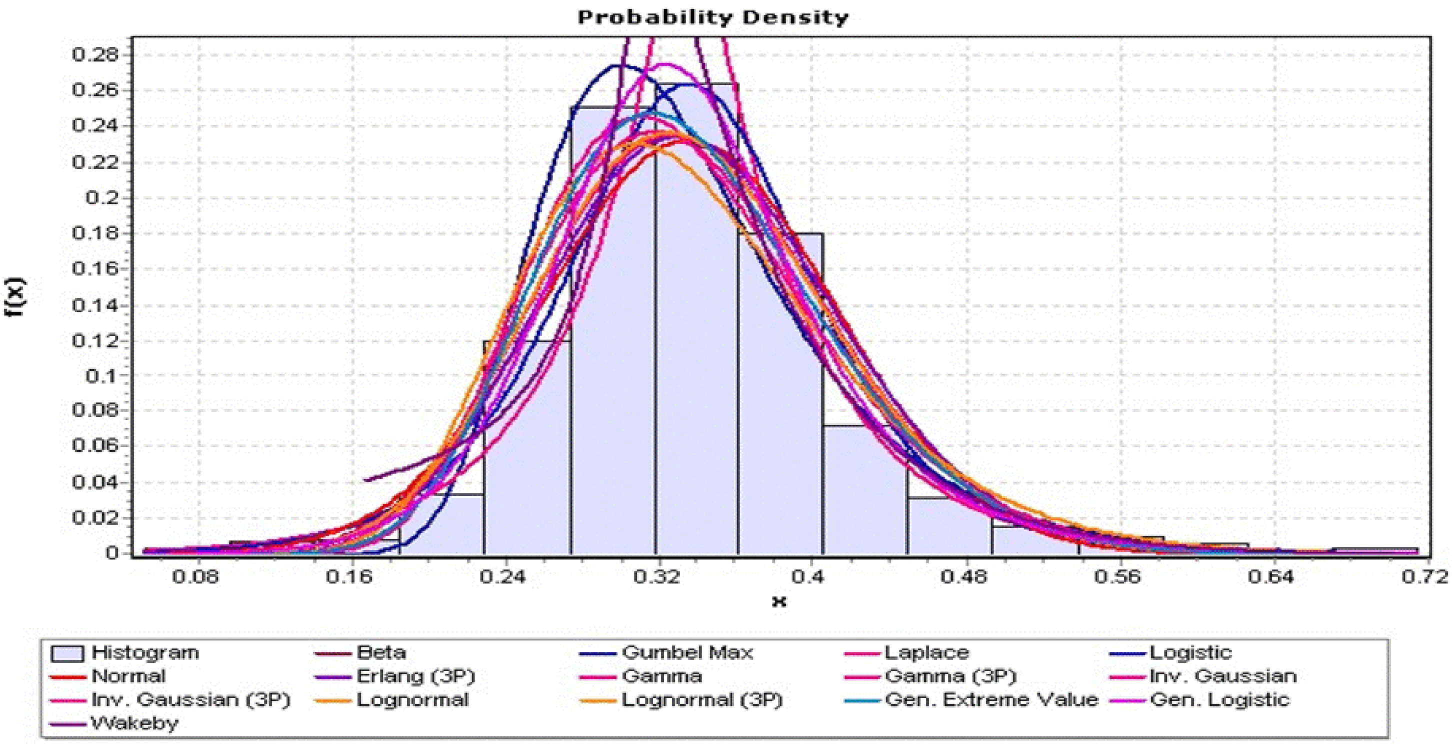


Fig. A.50 - Historic frequency distribution of averaged Eto for May.

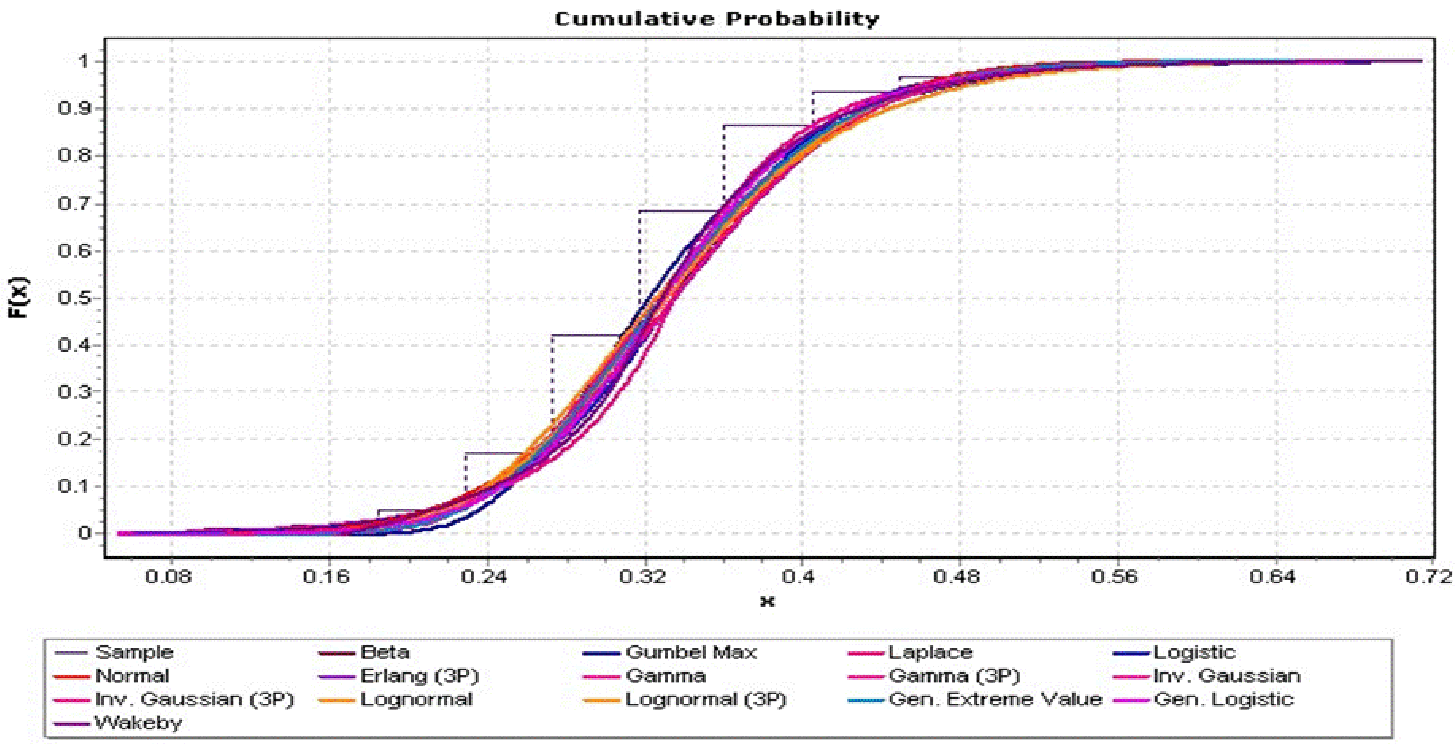


Fig. A.50 - (Continued).

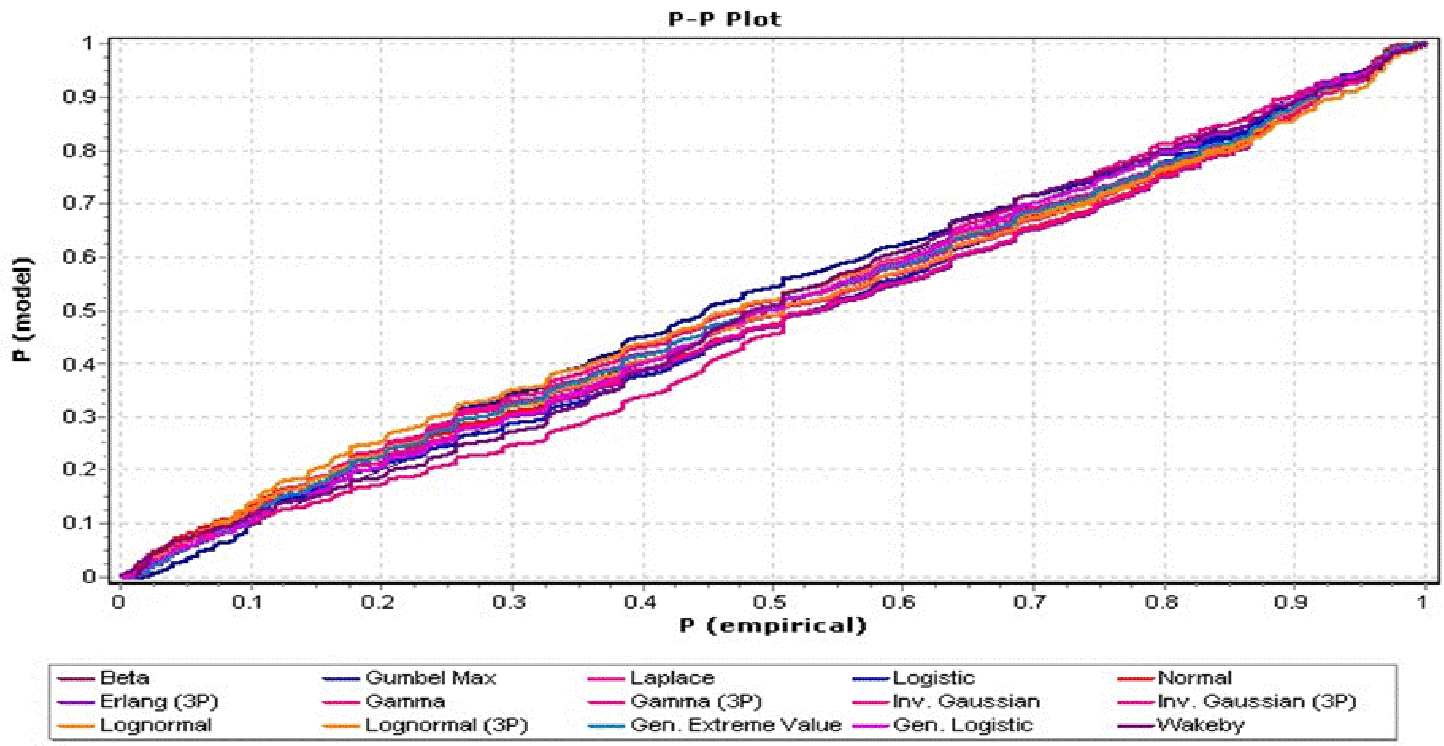


Fig. A.50 - (Continued).

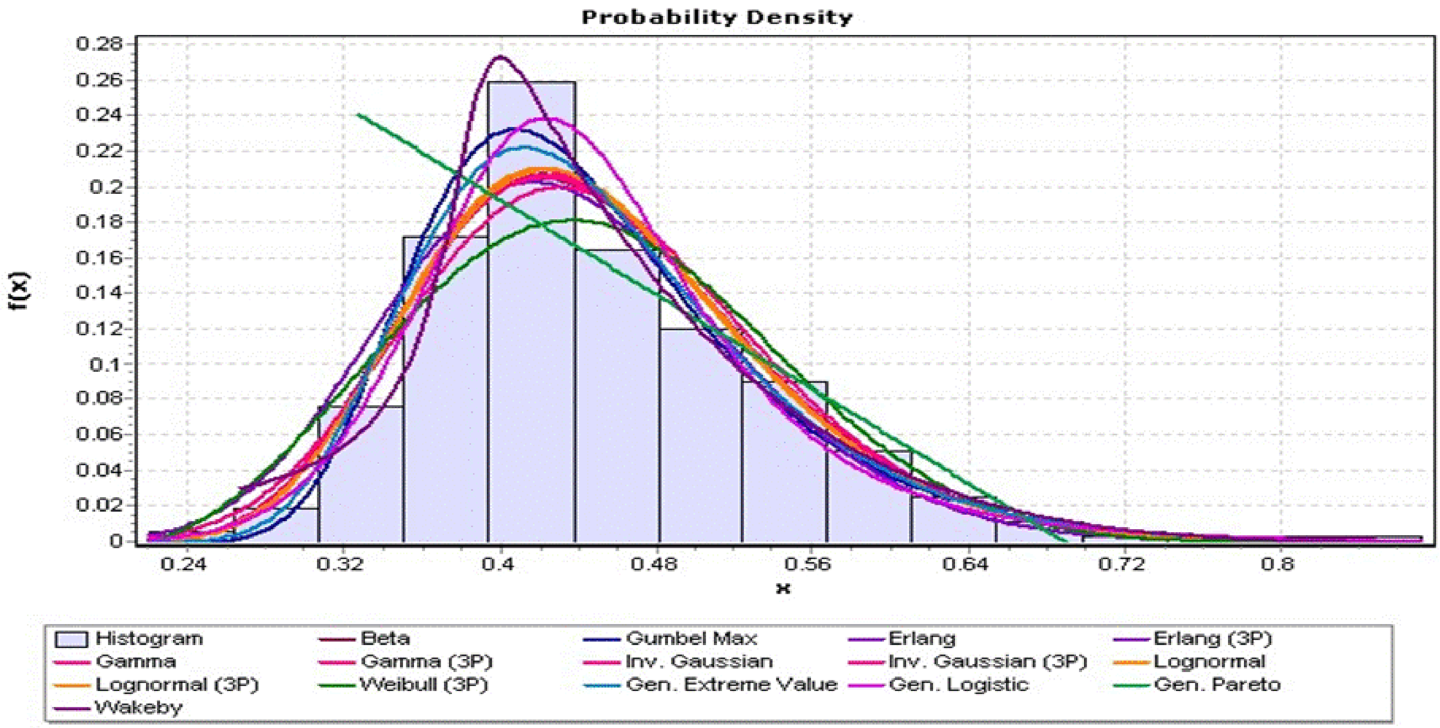


Fig. A.51 - Historic frequency distribution of averaged Eto for June.

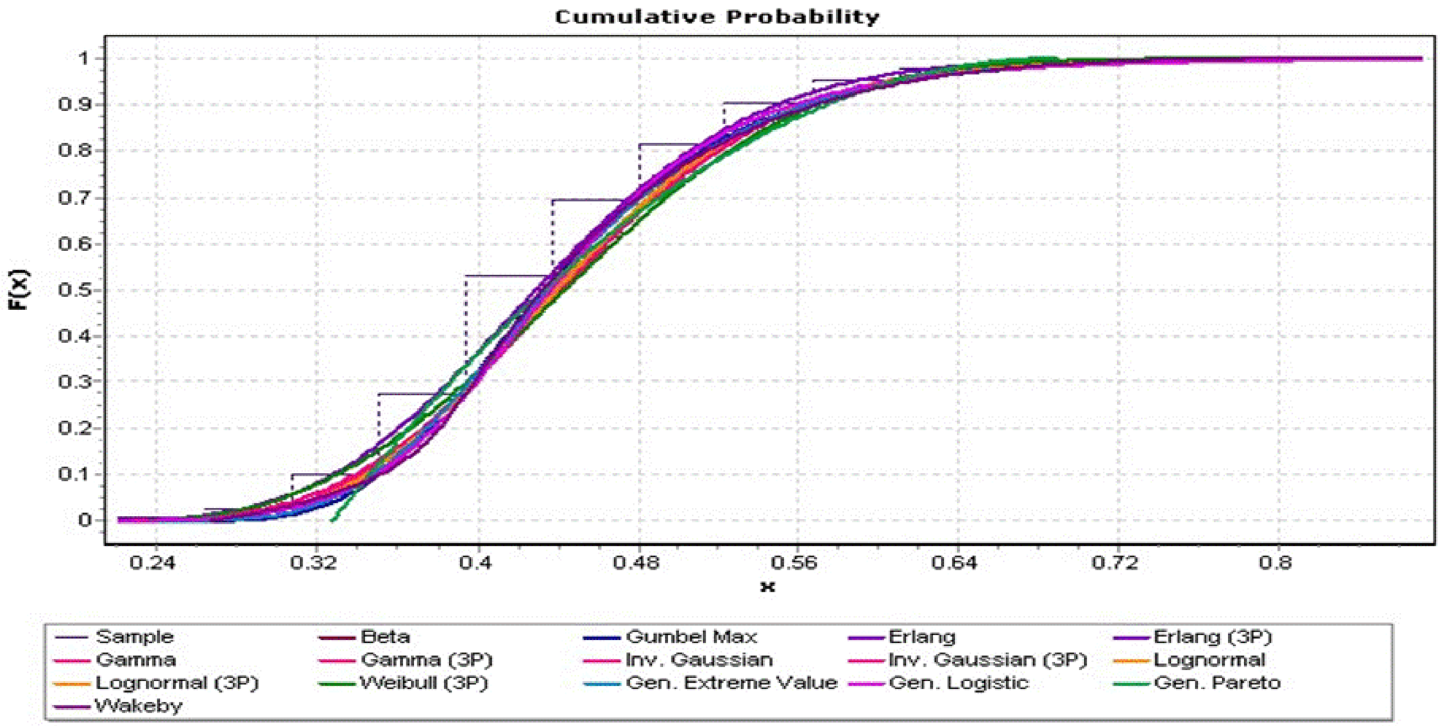


Fig. A.51 - (Continued).

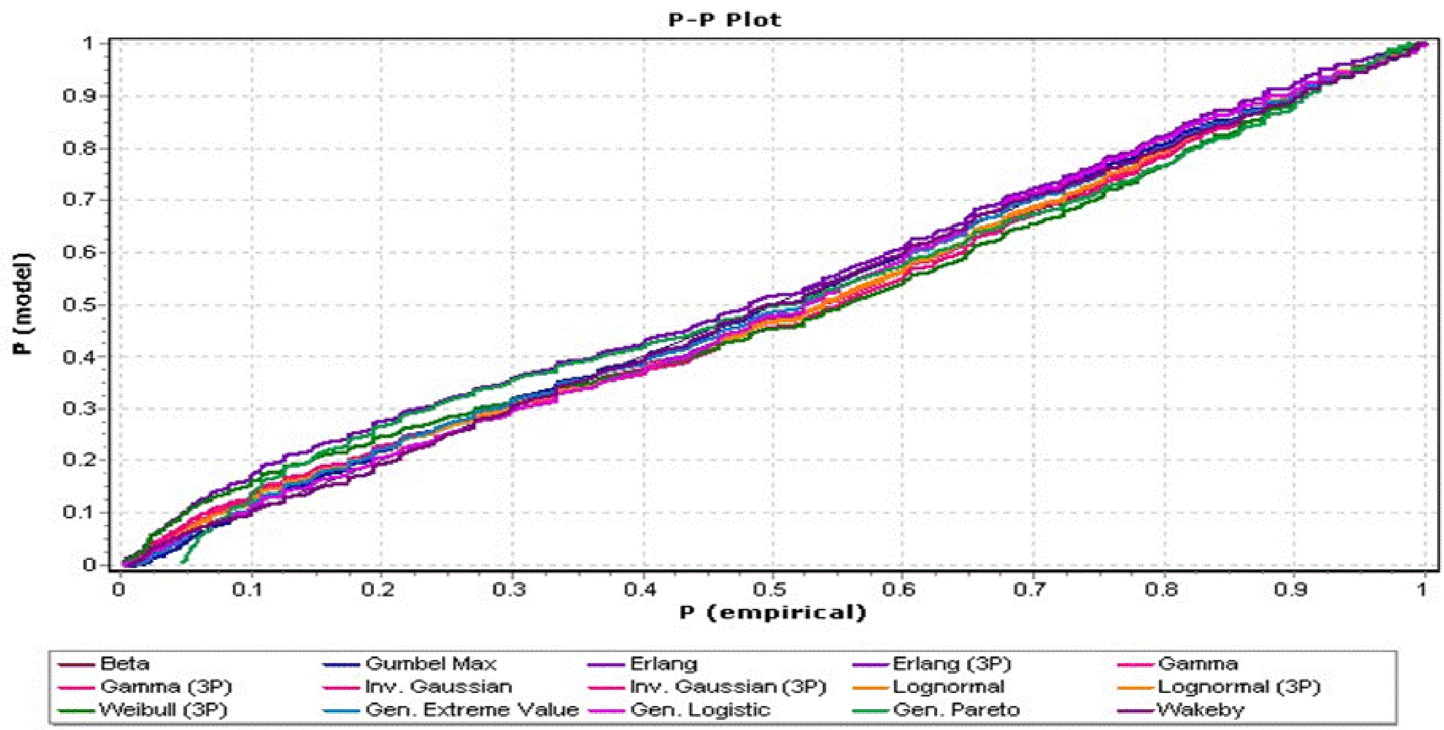


Fig. A.51 - (Continued).

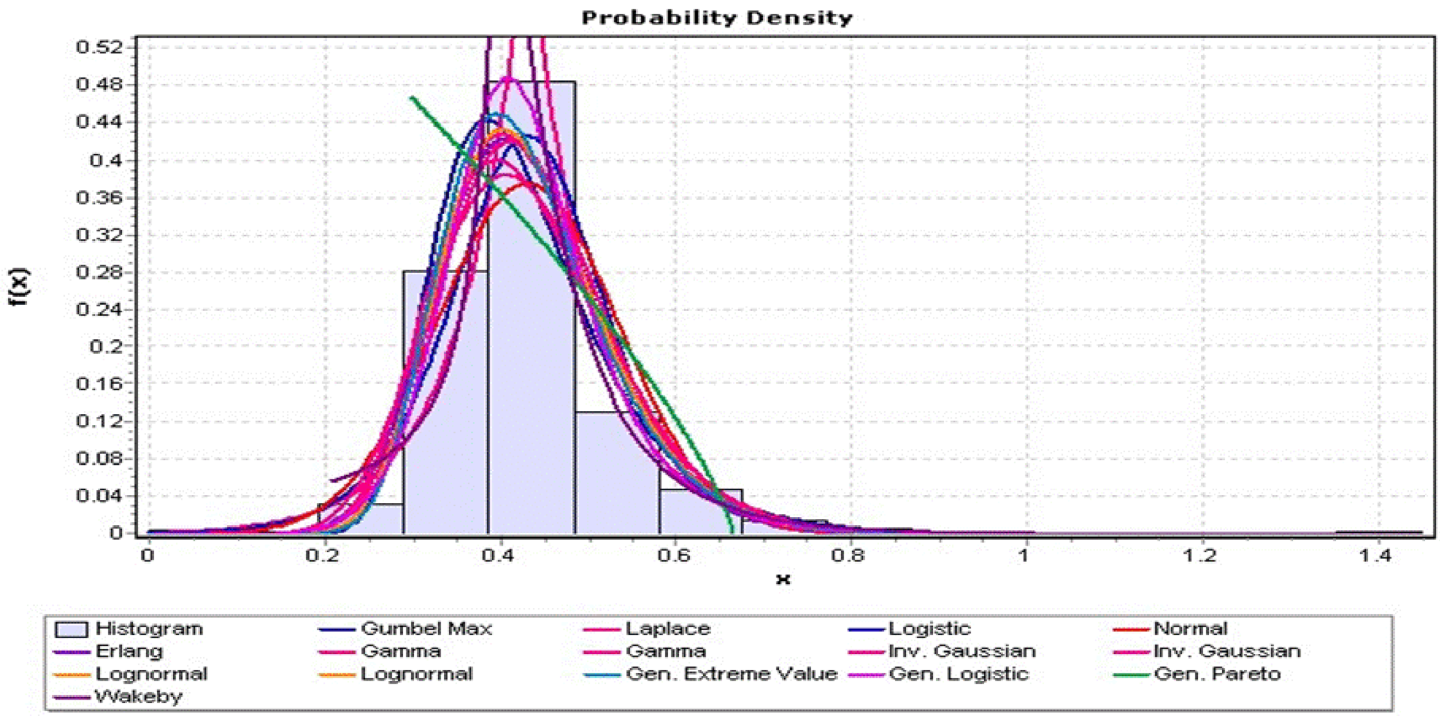


Fig. A.52 - Historic frequency distribution of averaged Eto for July.

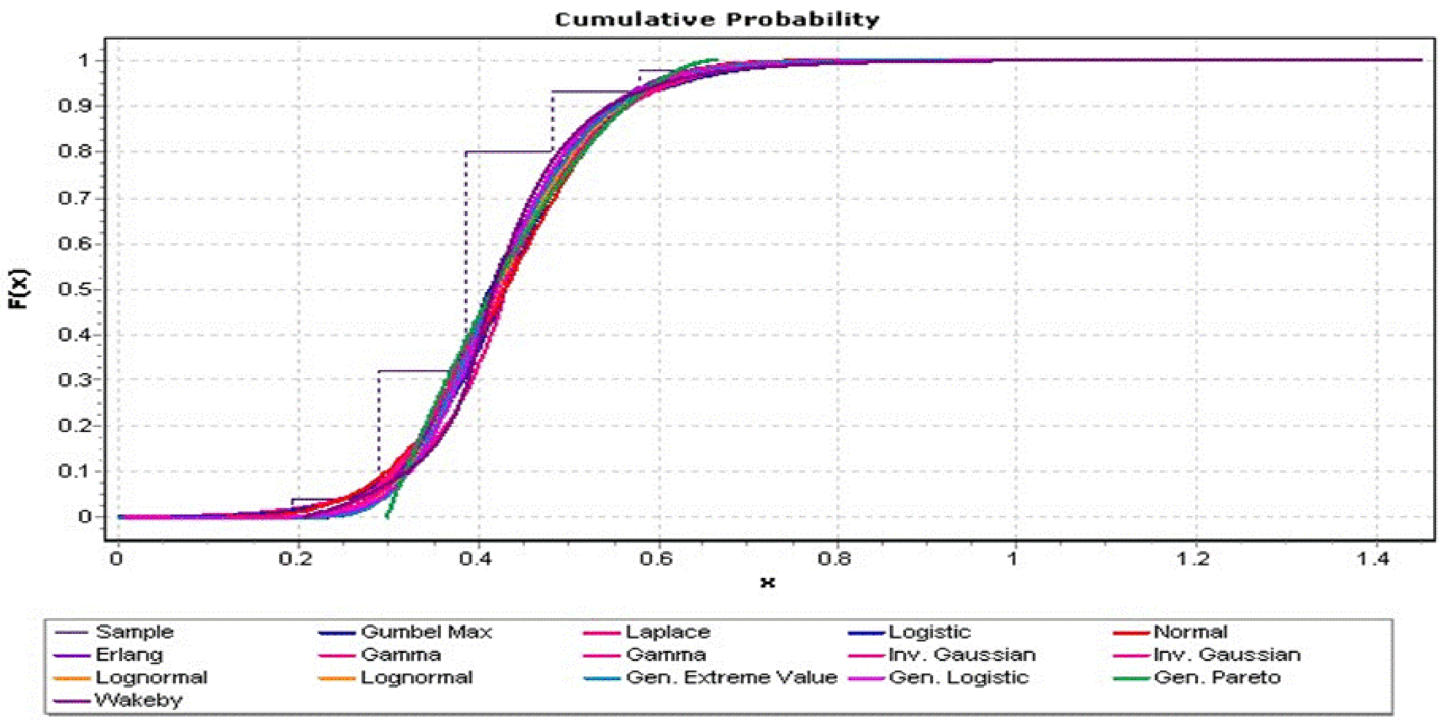


Fig. A.52 - (Continued).

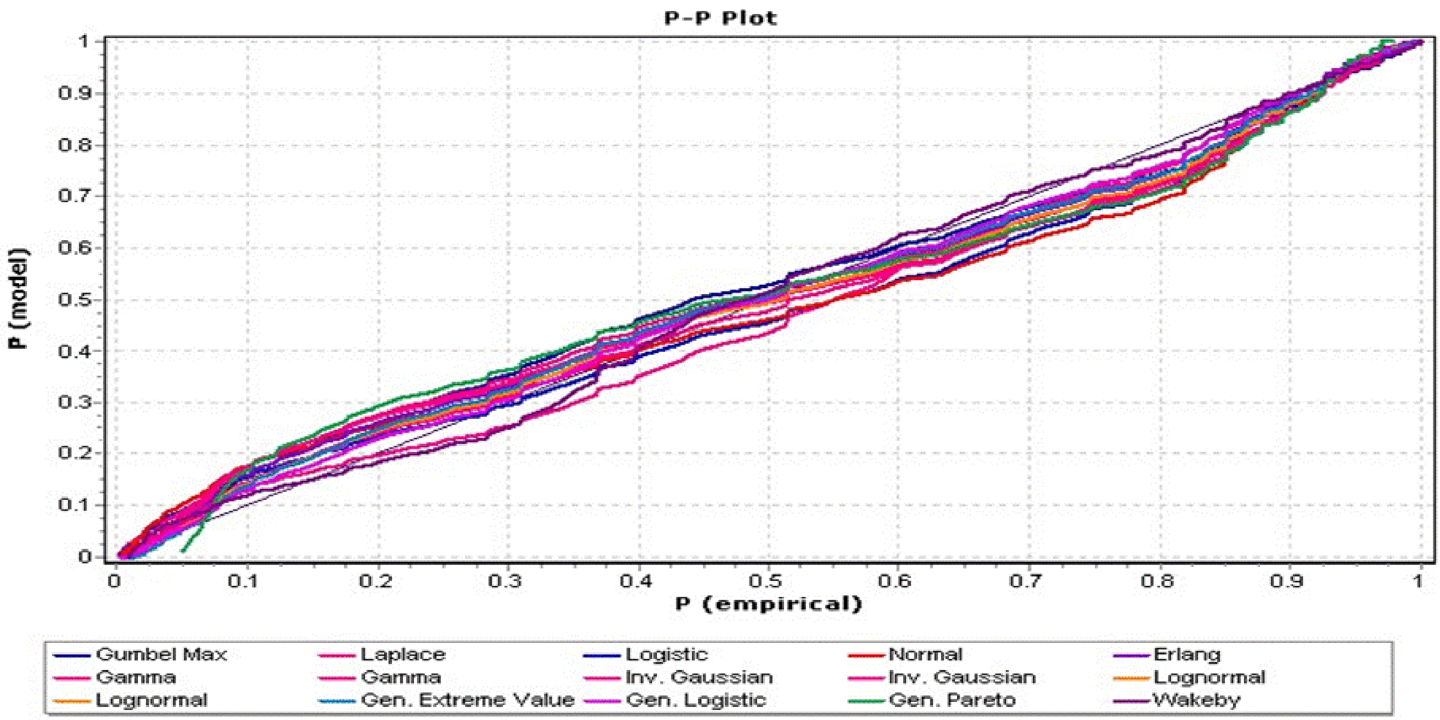


Fig. A.52 - (Continued).

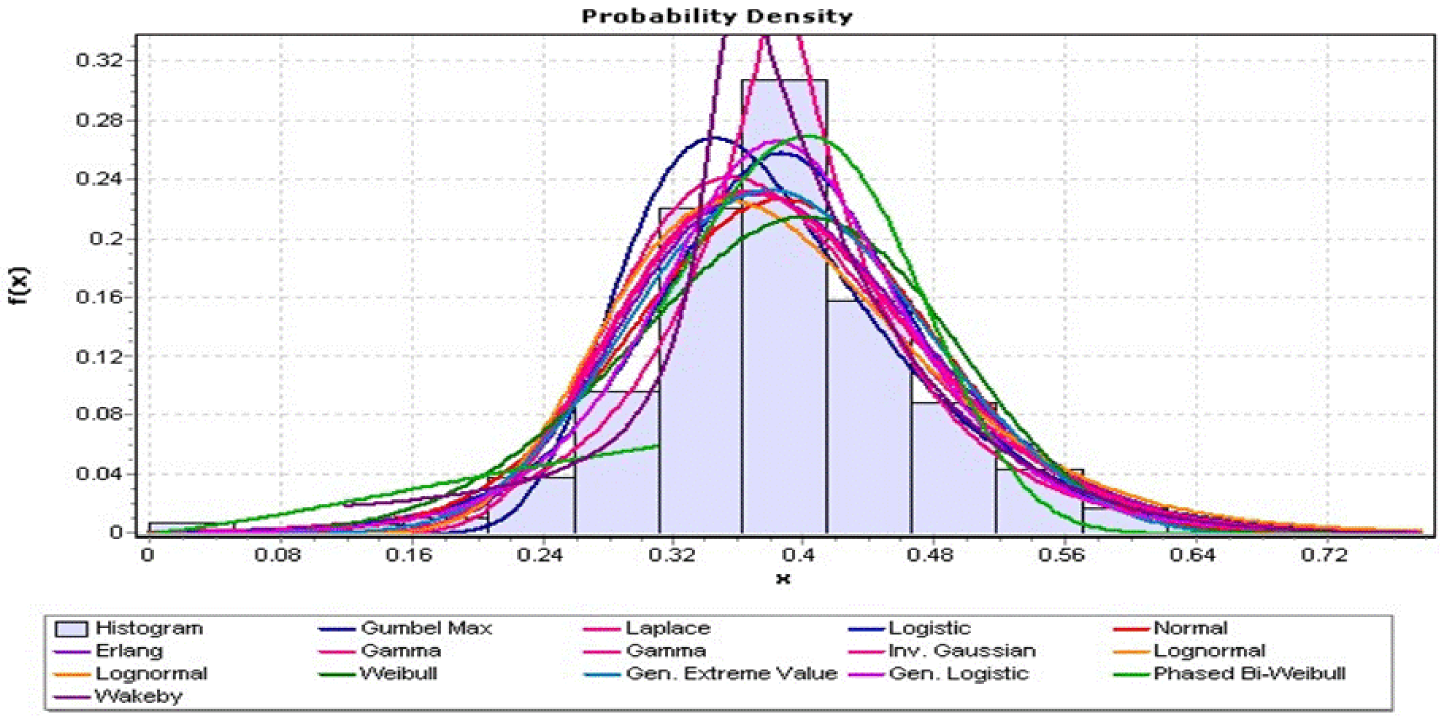


Fig. A.53 - Historic frequency distribution of averaged Eto for August.

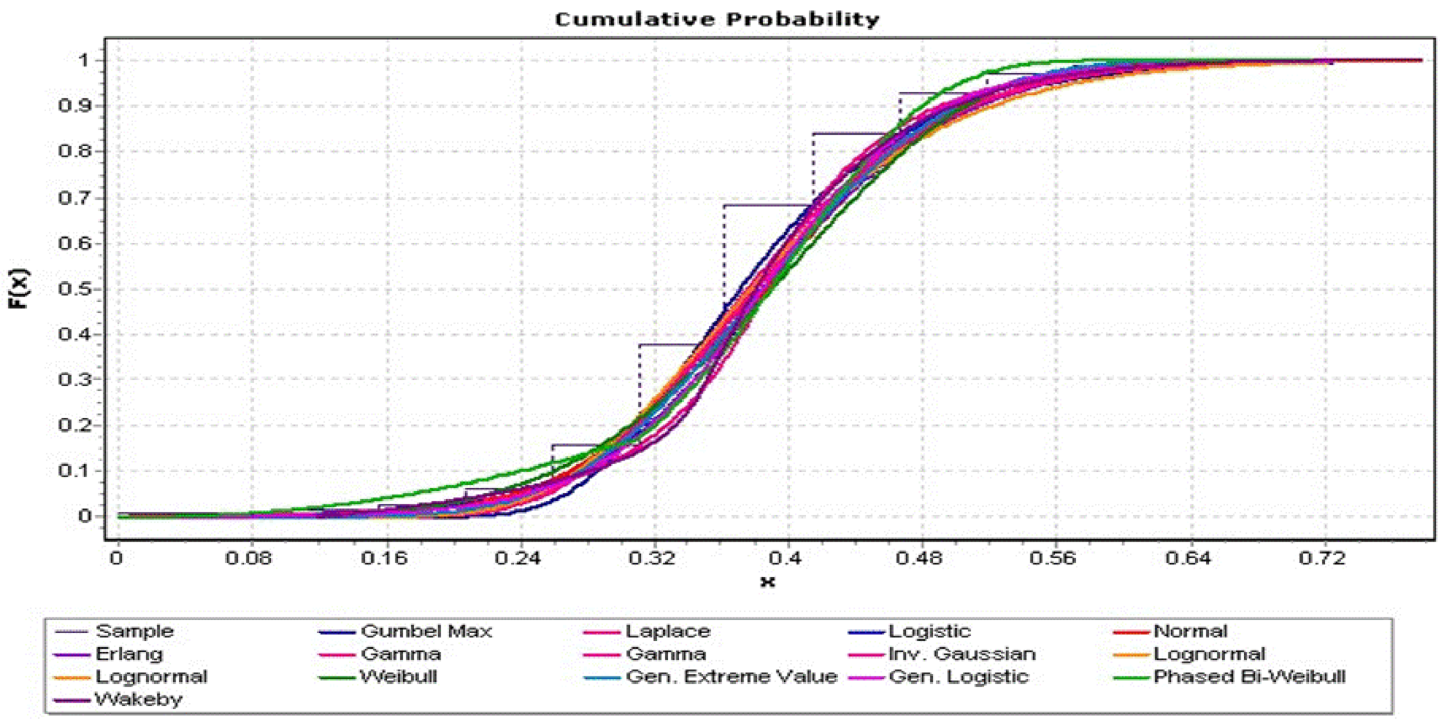


Fig. A.53 - (Continued).

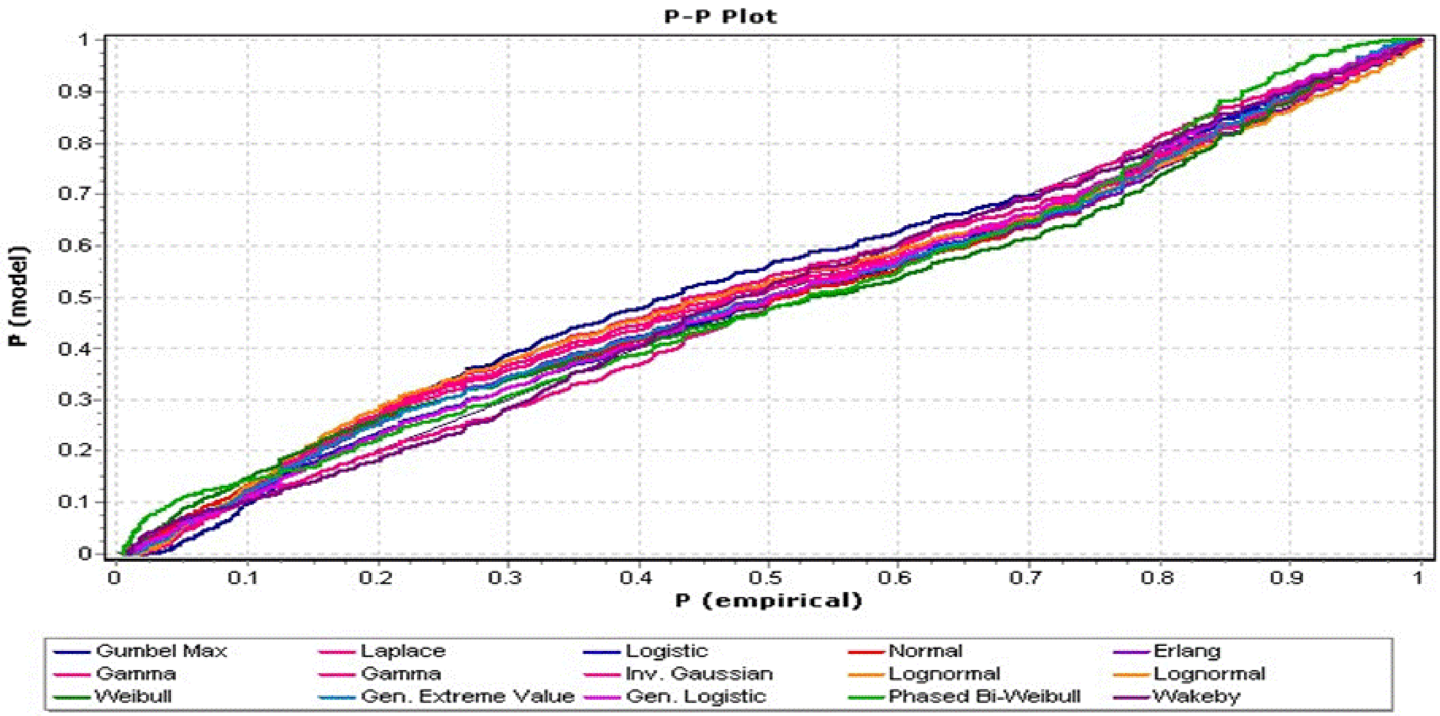


Fig. A.53 - (Continued).

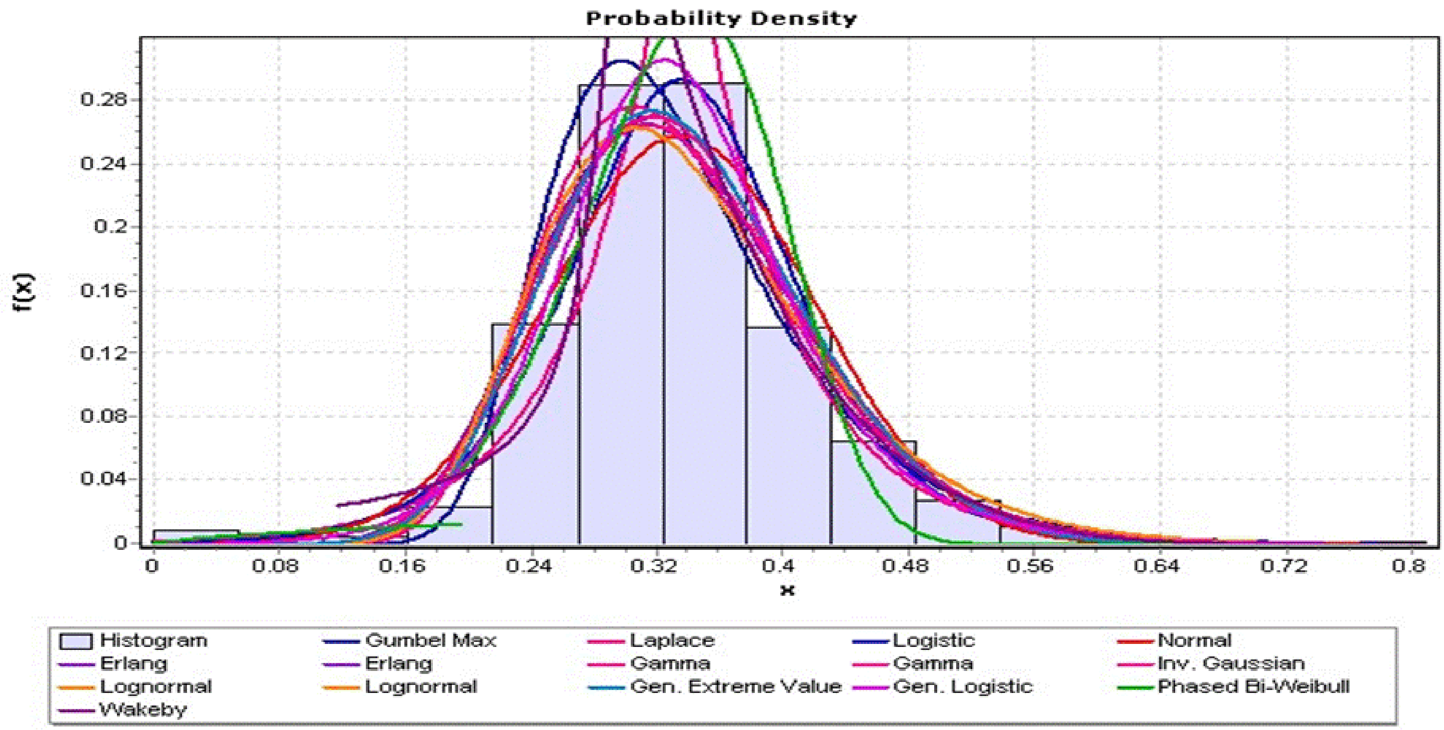


Fig. A.54 - Historic frequency distribution of averaged Eto for September.

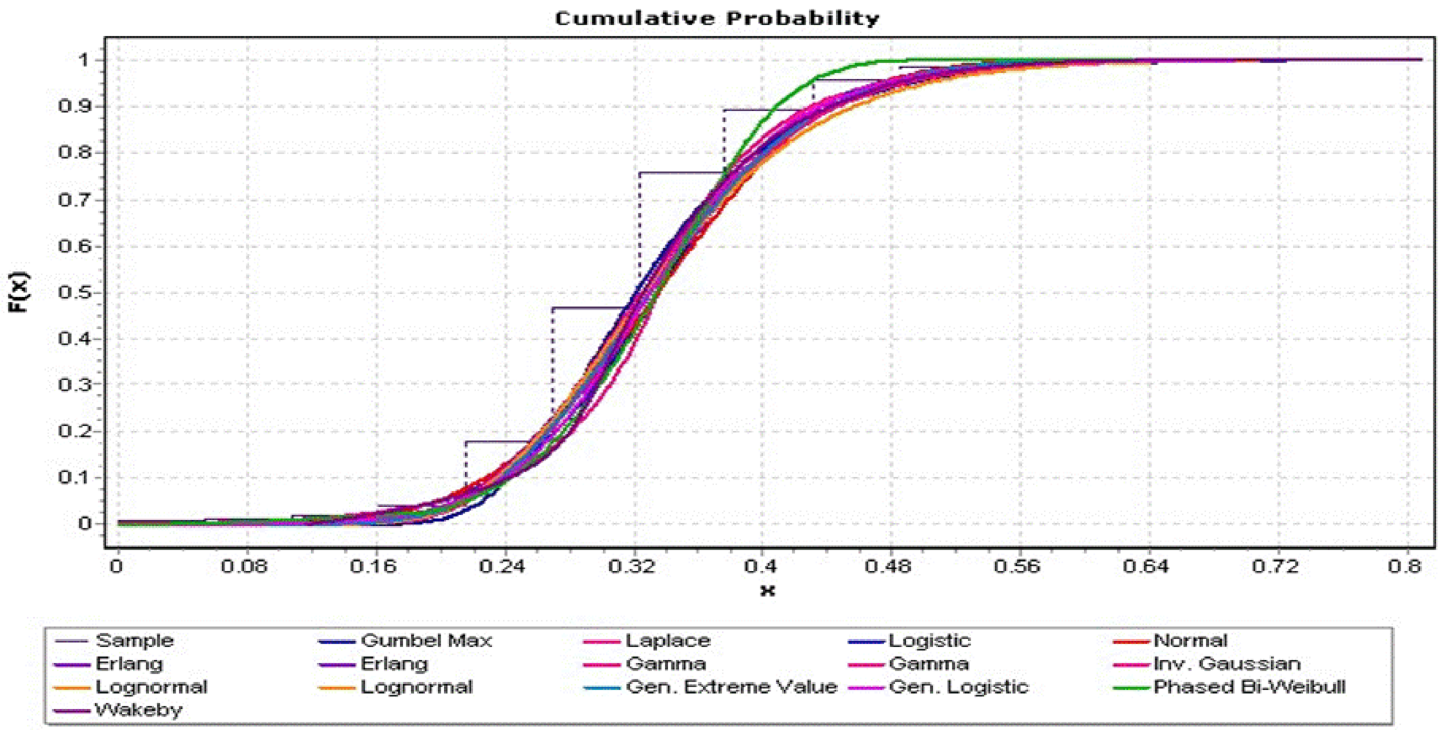


Fig. A.54 - (Continued).

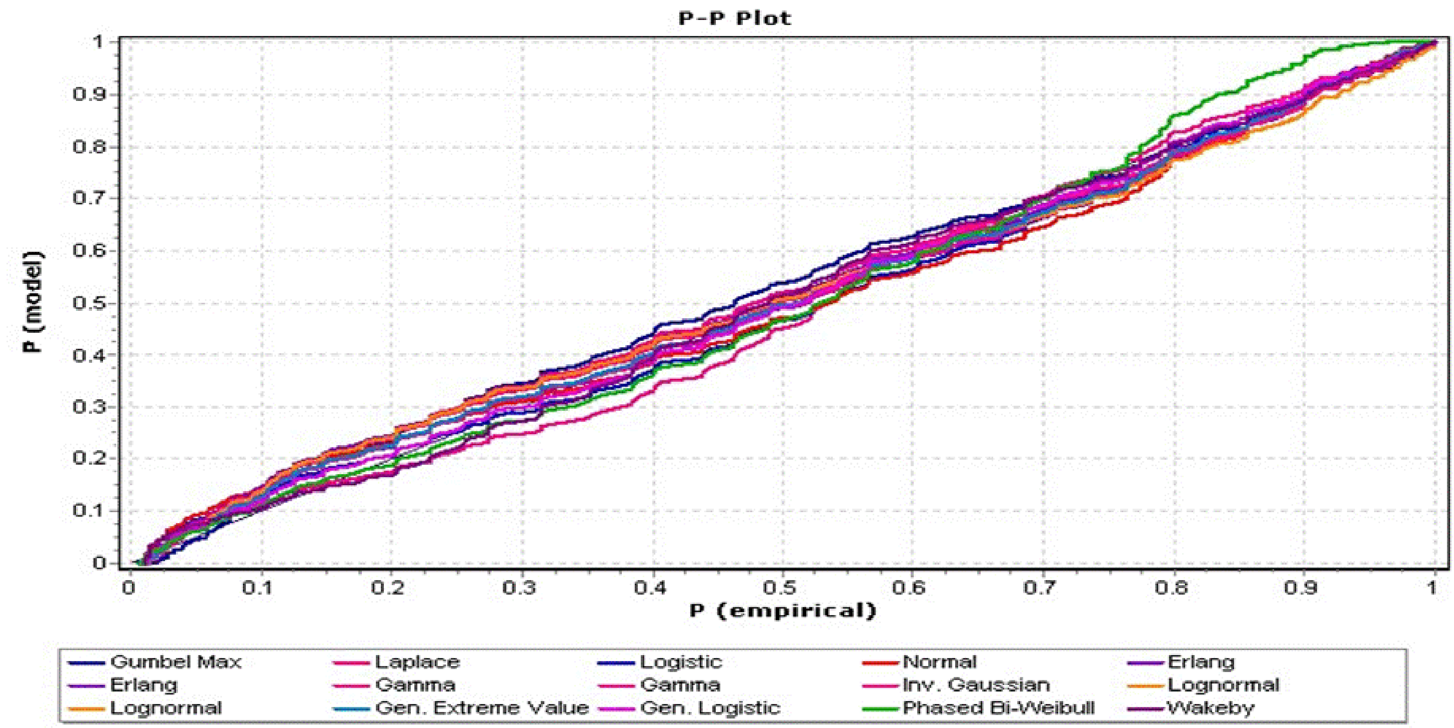


Fig. A.54 - (Continued).

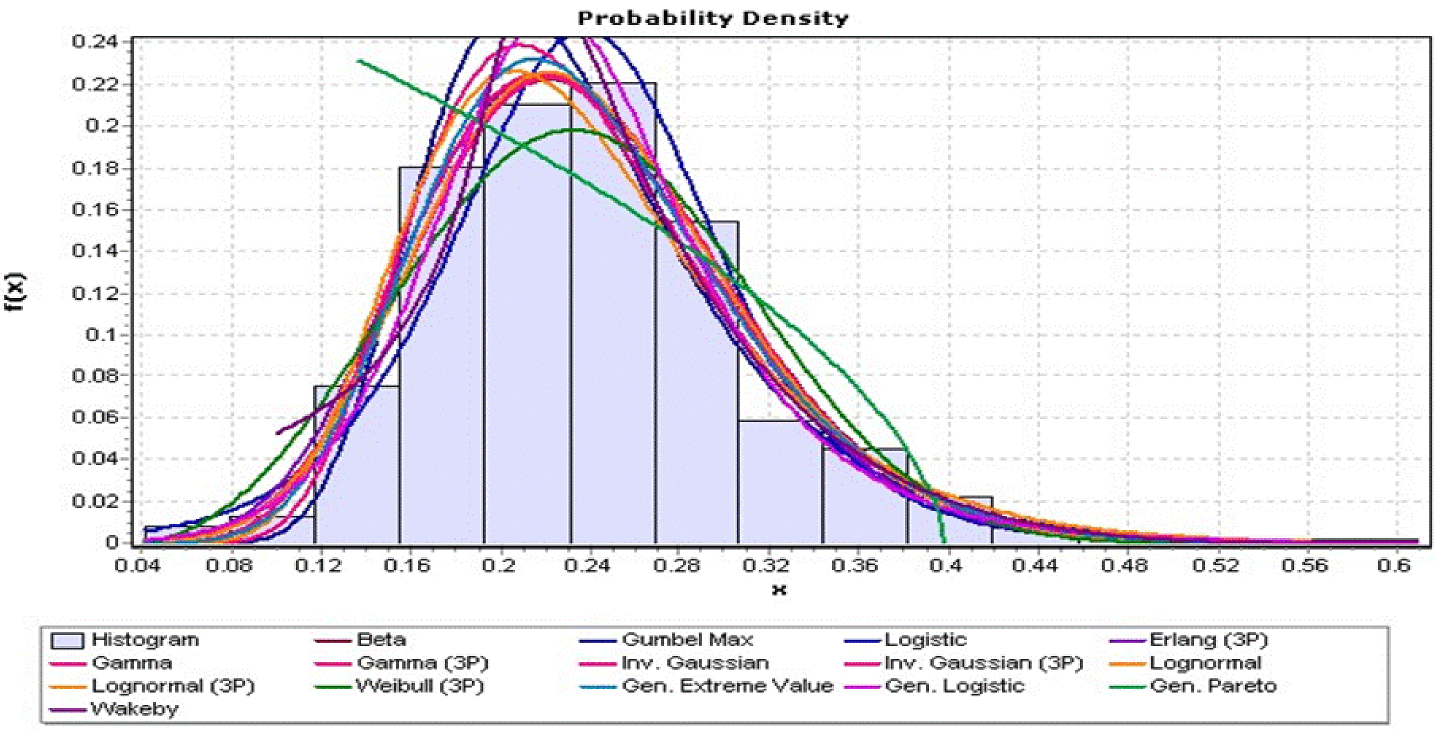


Fig. A.55 - Historic frequency distribution of averaged Eto for October.

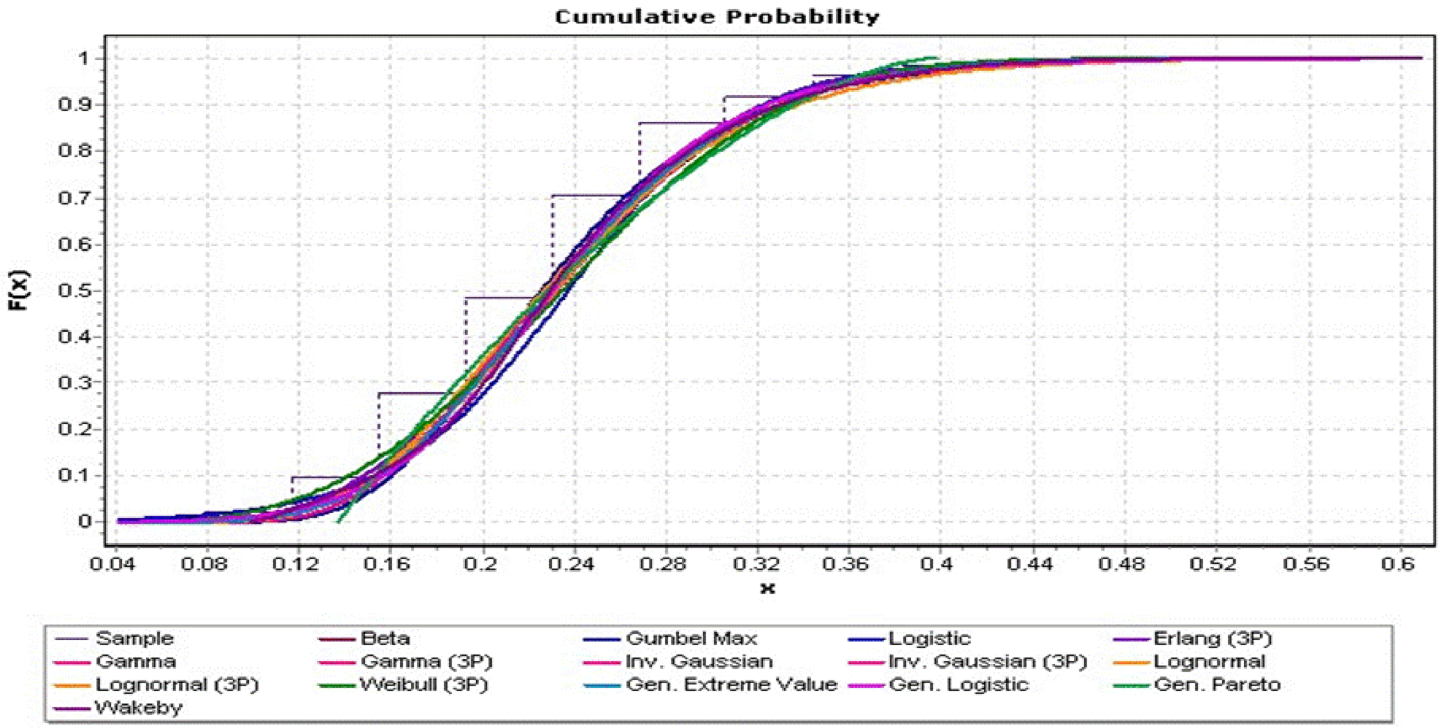
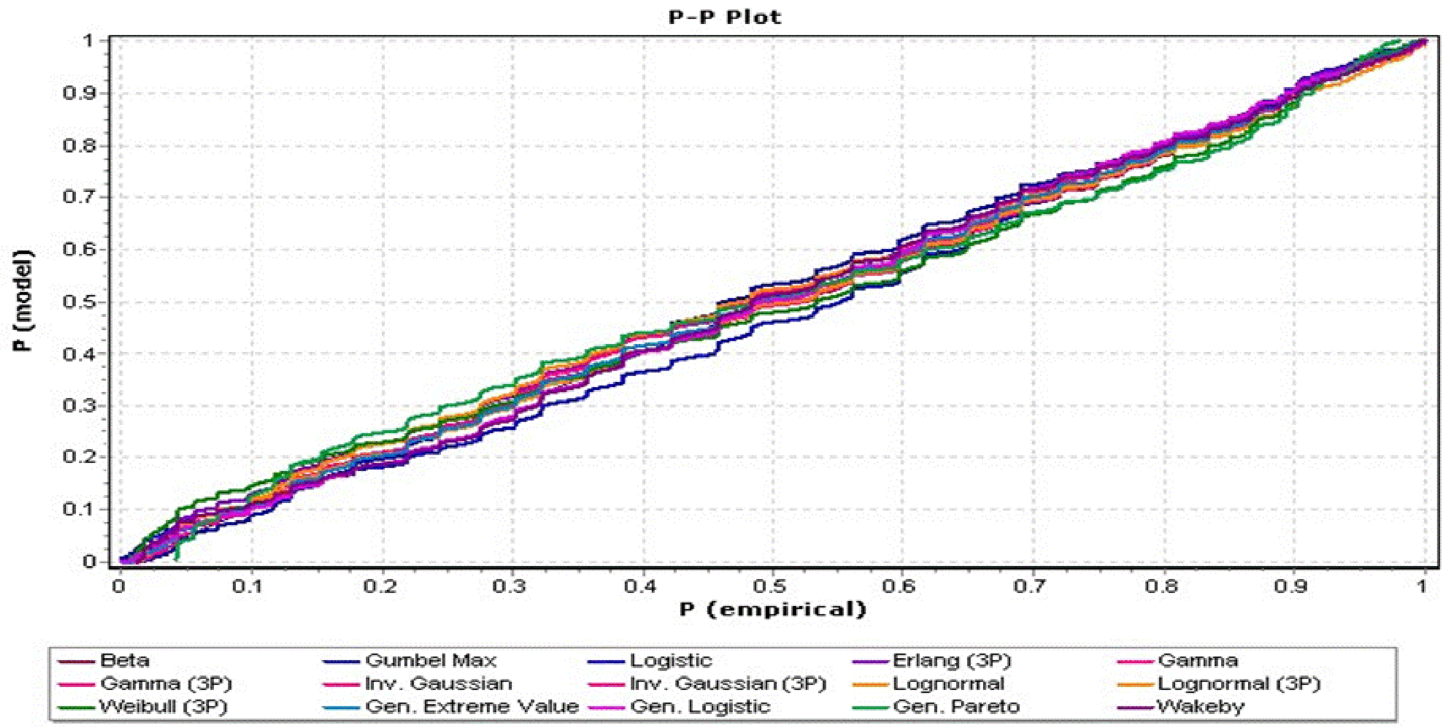


Fig. A.55 - (Continued).



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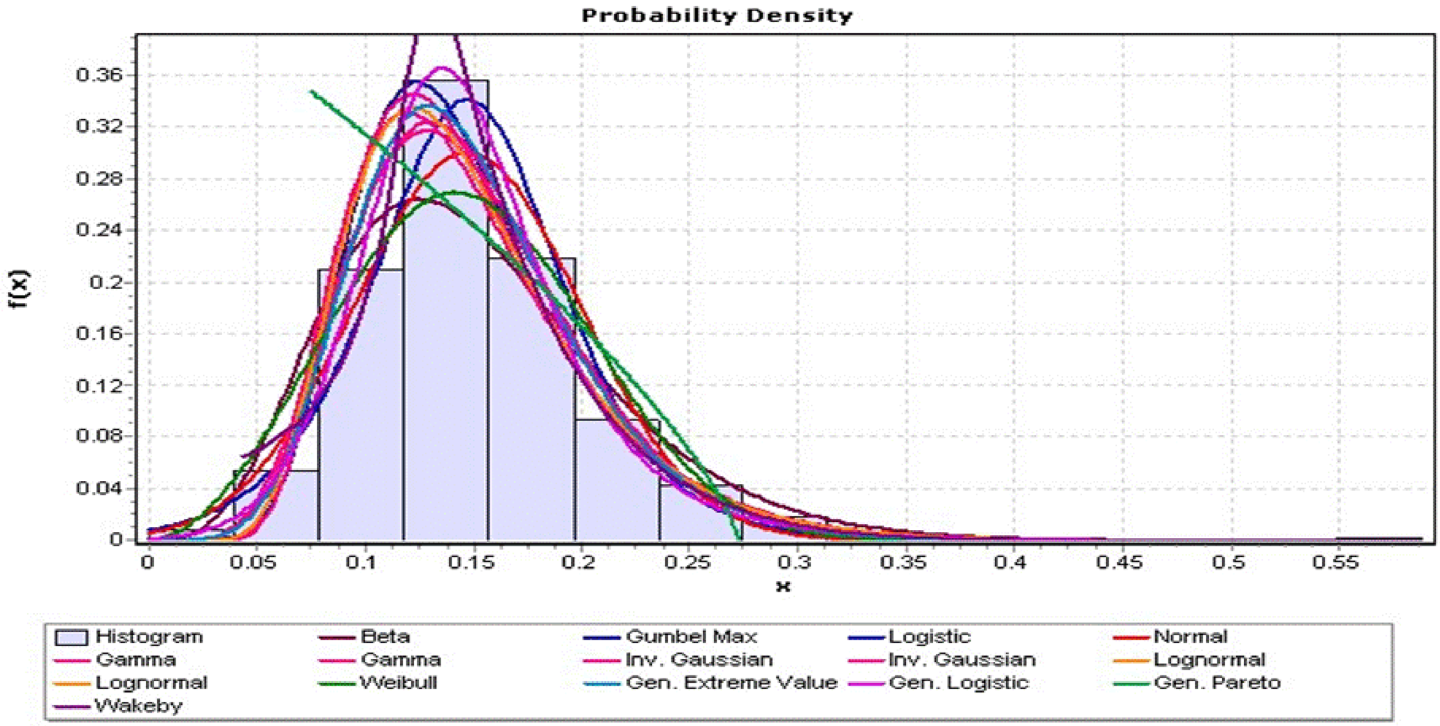


Fig. A.56 - Historic frequency distribution of averaged Eto for November.

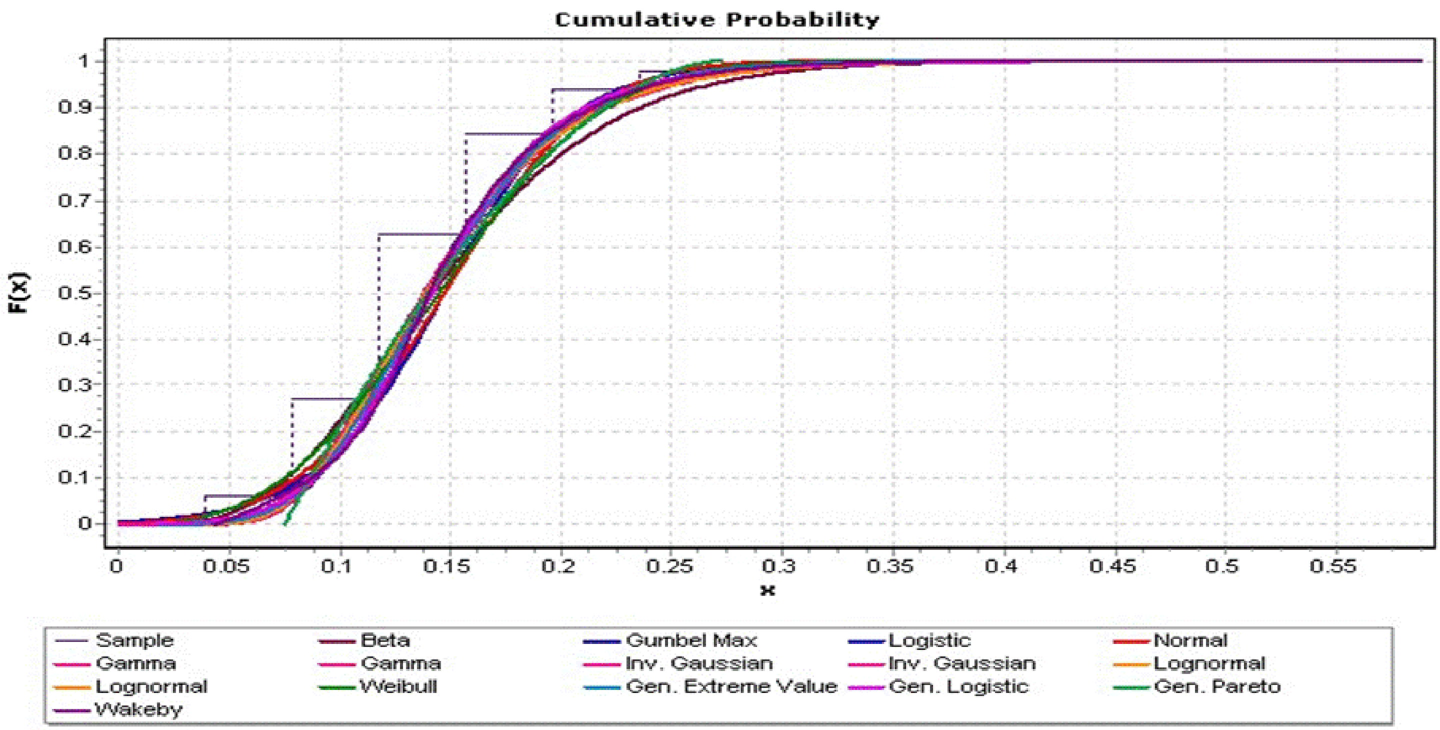


Fig. A.56 - (Continued).

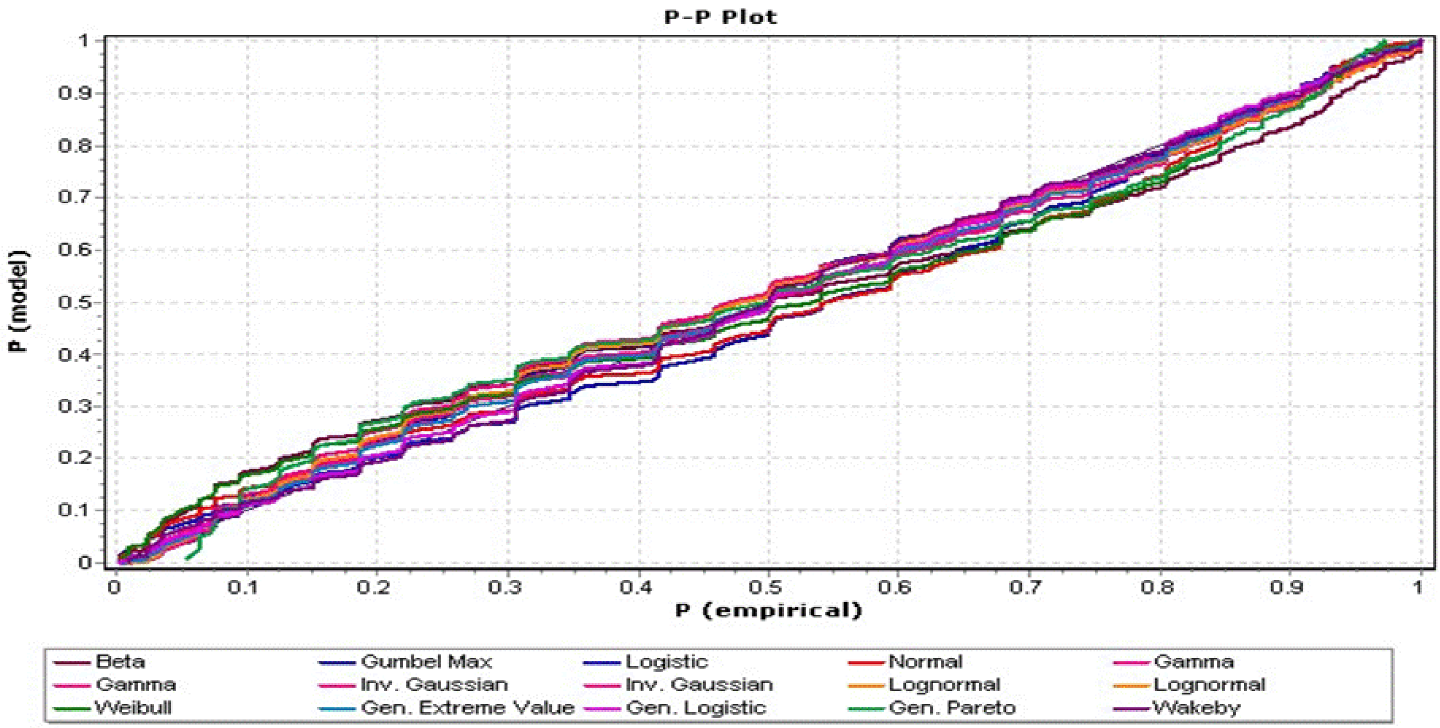


Fig. A.56 - (Continued).

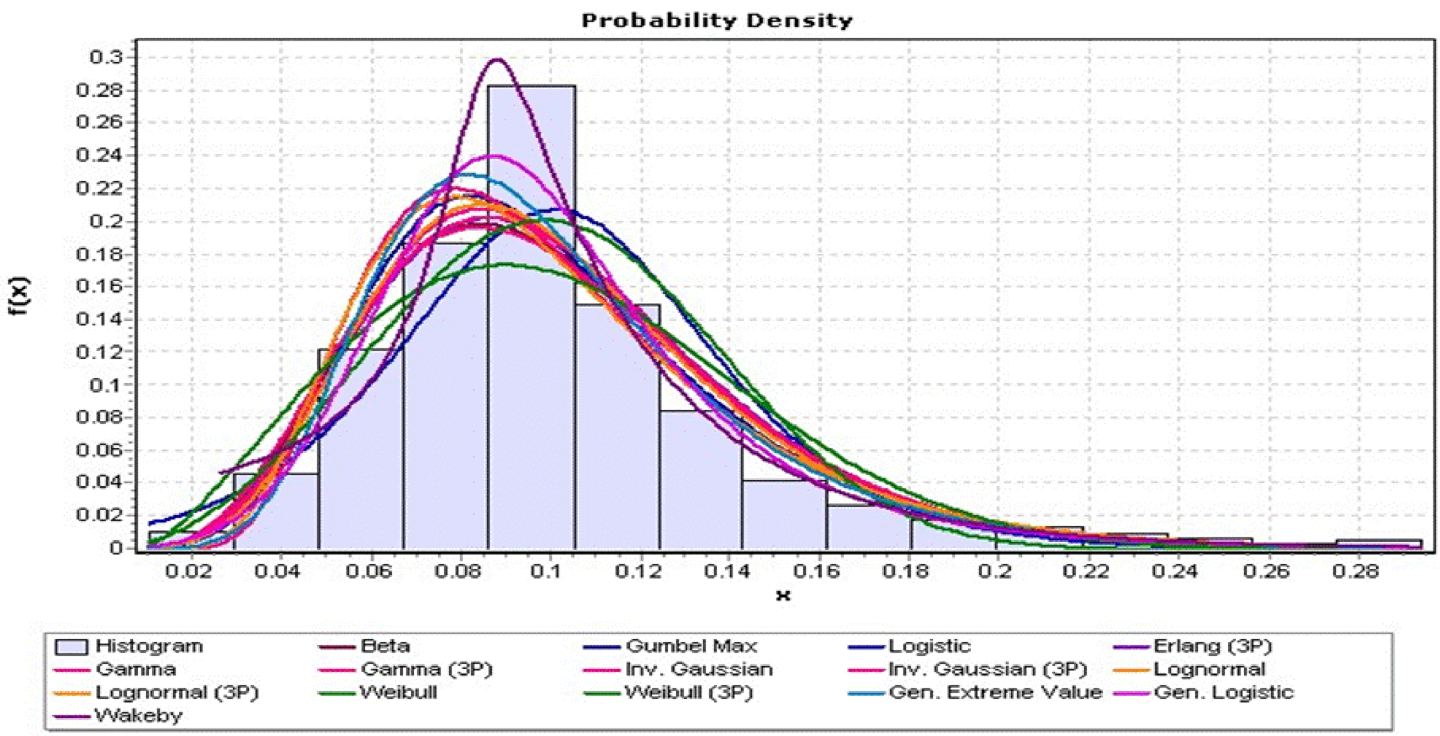


Fig. A.57 - Historic frequency distribution of averaged Eto for December.

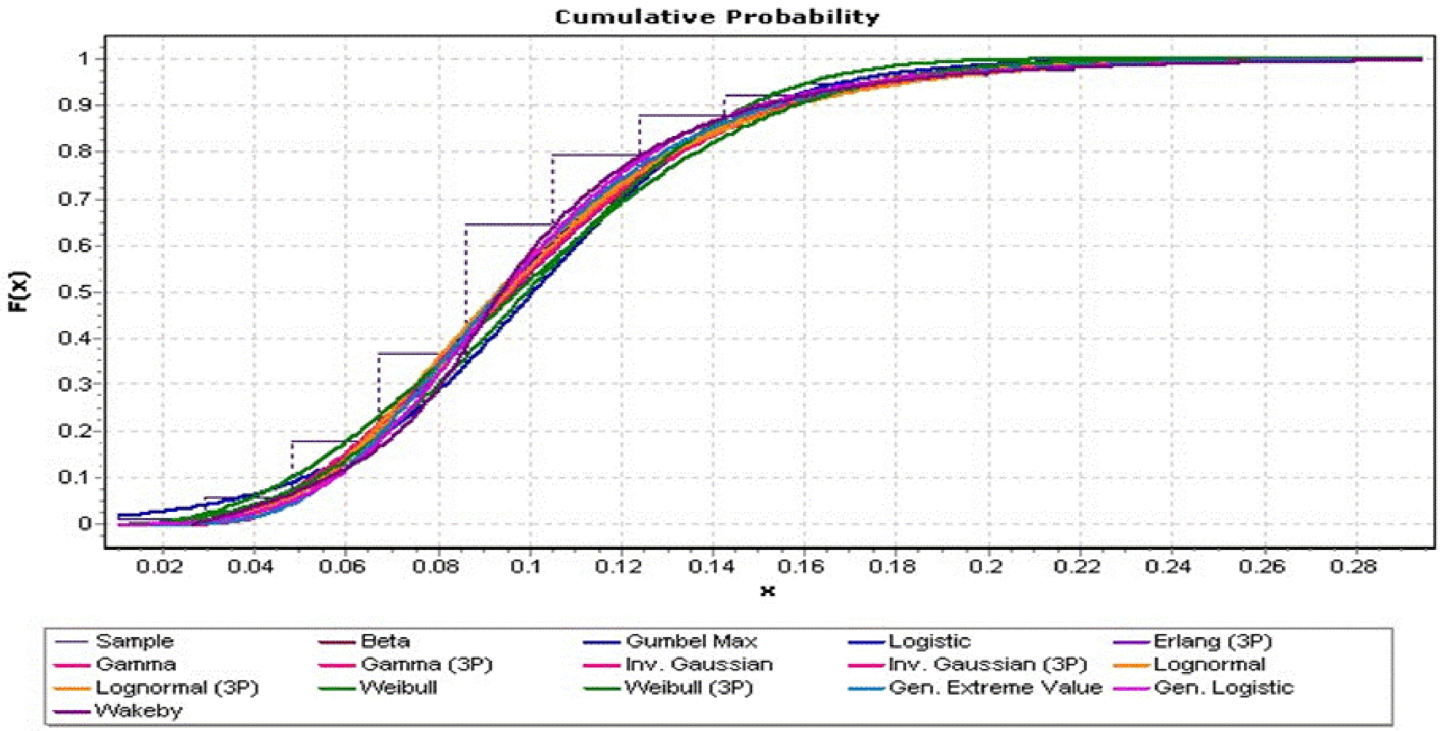
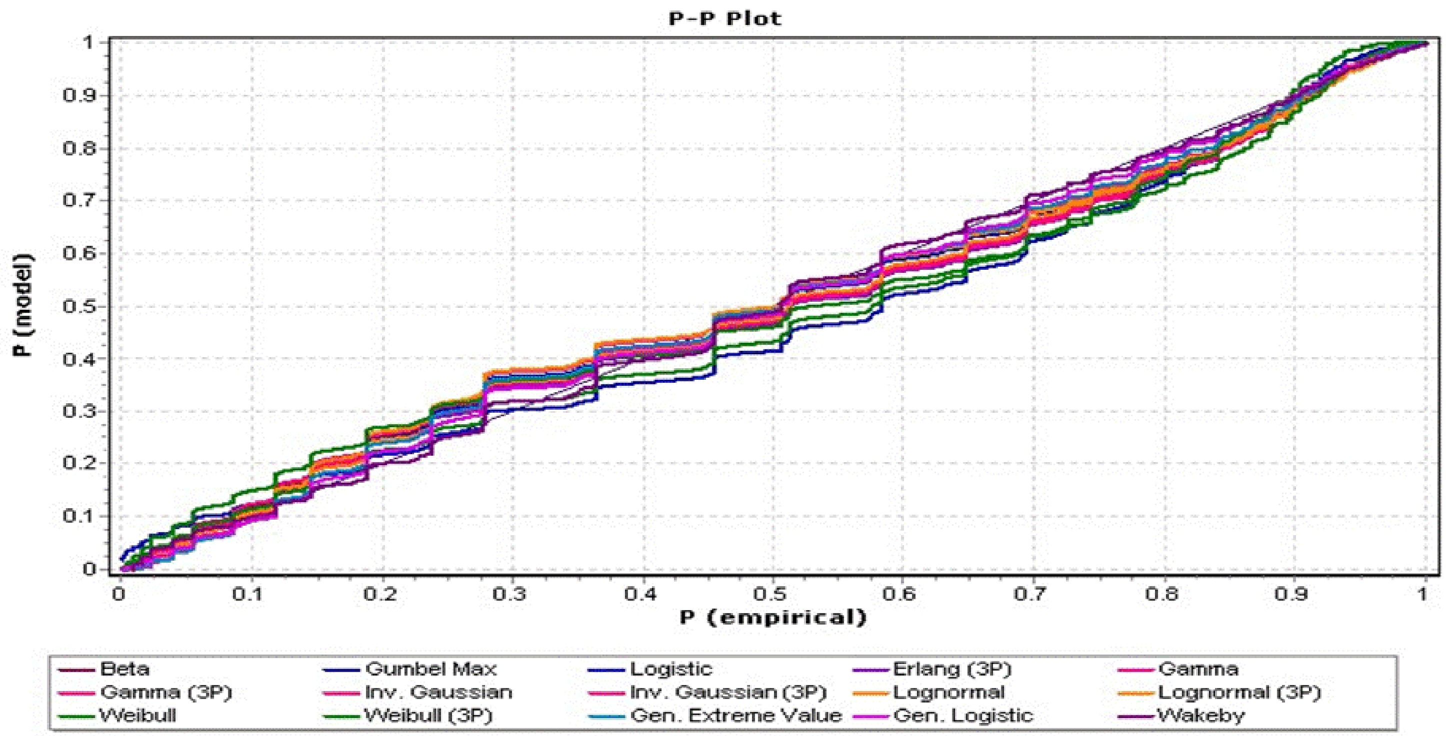


Fig. A.57 - (Continued).



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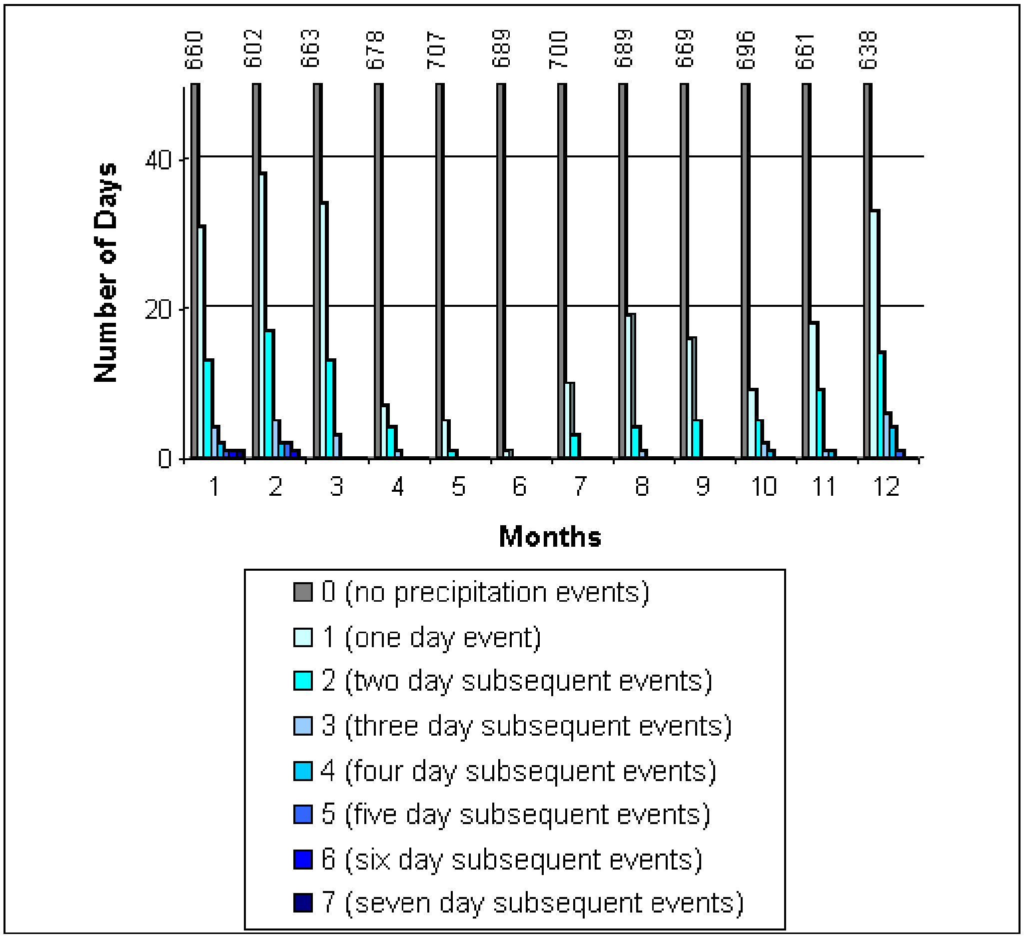


Fig. A.58 - Analysis of the variables 'Month' and 'CatEvent' based on the Brawley-Calipatria weather station dataset (1982-2004).

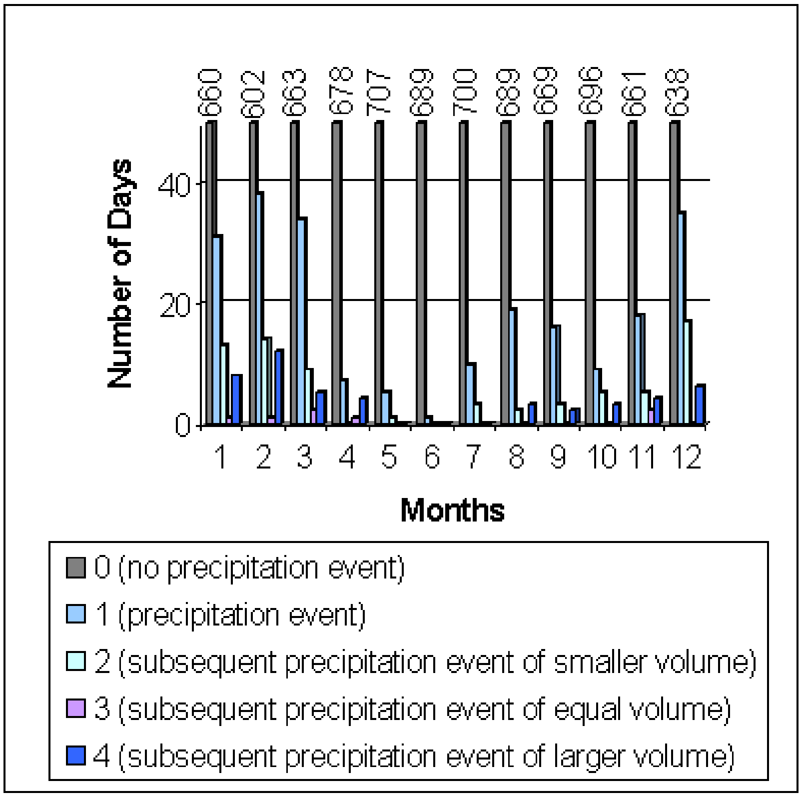


Fig. A.59 - Analysis of the variables 'Month' and 'CatVol' based on the Brawley-Calipatria weather station dataset (1982-2004).

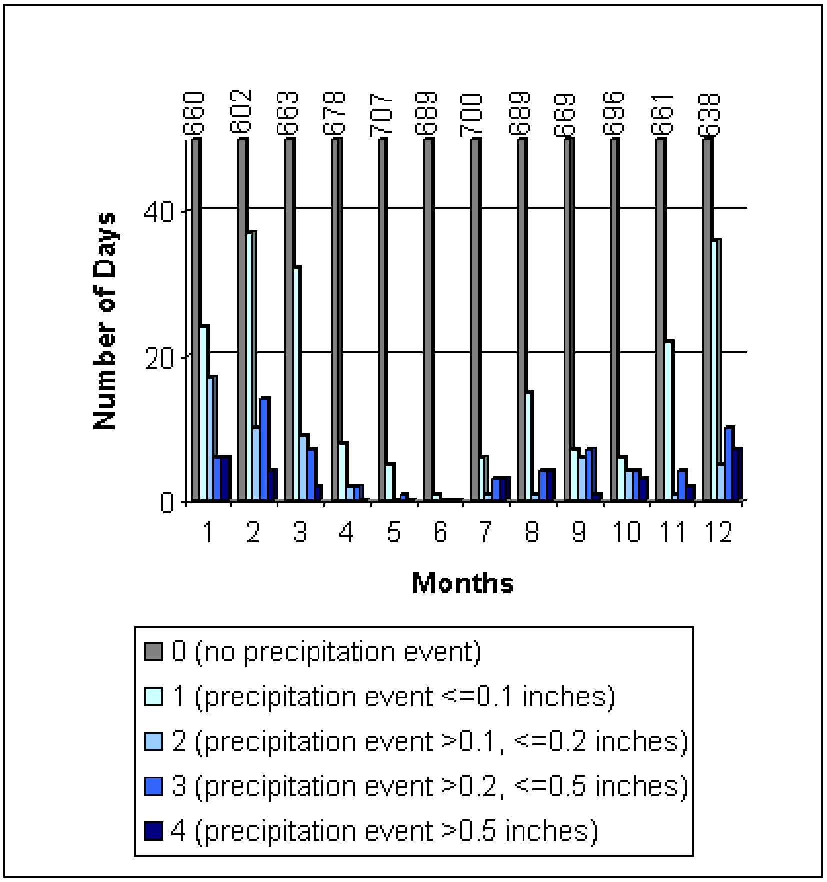


Fig. A.60 - Analysis of the variables ‘Month’ and ‘PrcpAmt’ based on the Brawley-Calipatria weather station dataset (1982-2004).

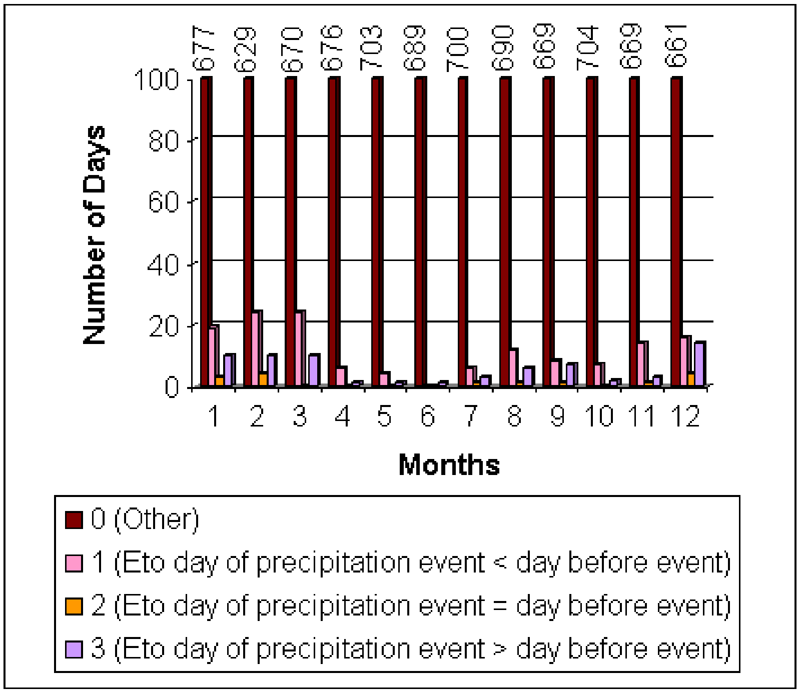


Fig. A.61 - Analysis of the variables ‘Month’ and ‘EtoFirst’ based on the Brawley-Calipatria weather station dataset (1982-2004).

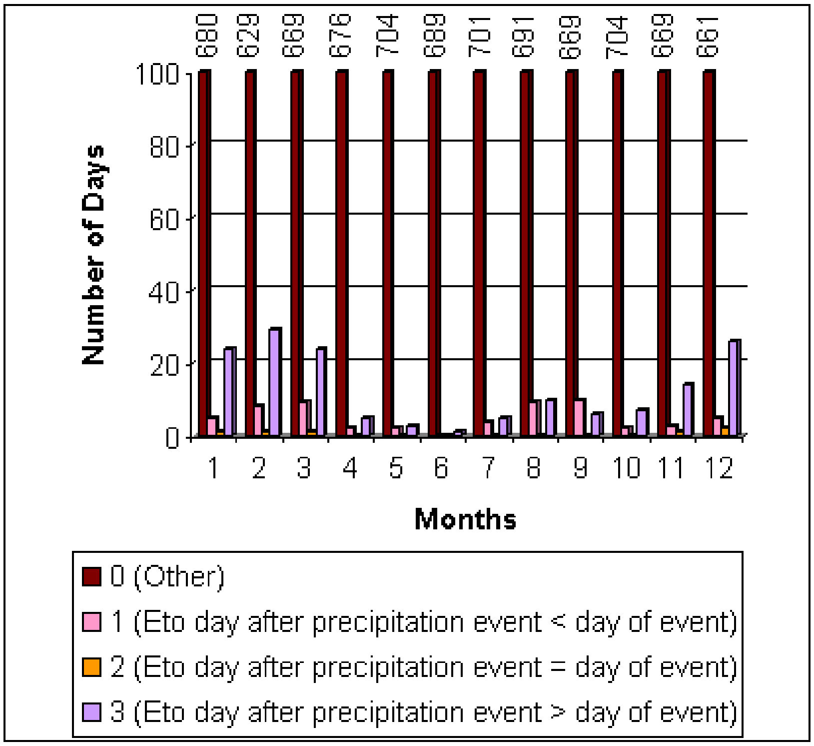


Fig. A.62 - Analysis of the variables 'Month' and 'Etolev2' based on the Brawley-Calipatria weather station dataset (1982-2004).

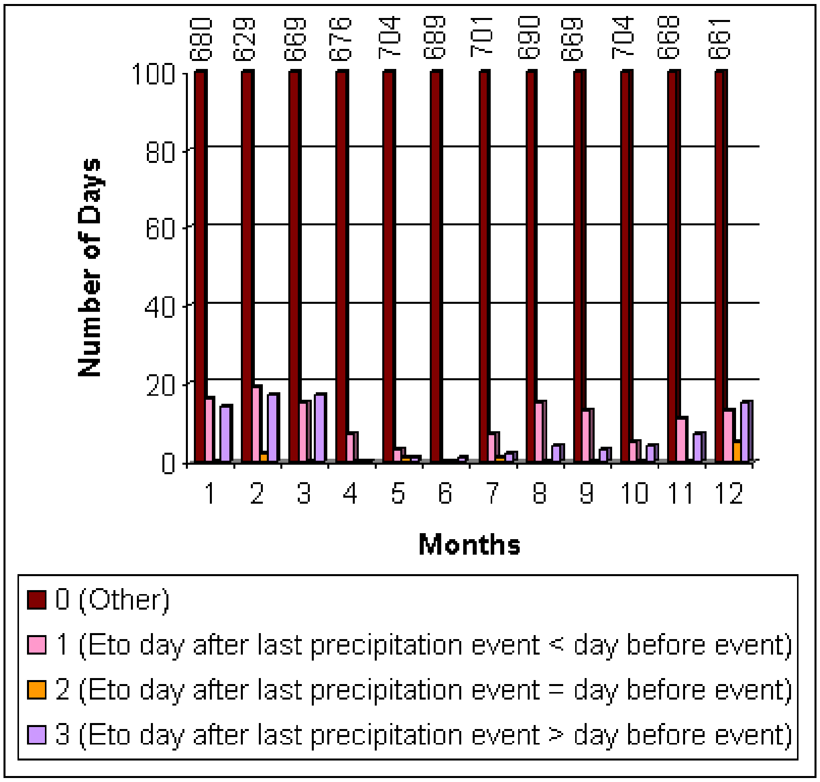


Fig. A.63 - Analysis of the variables 'Month' and 'EtoOne' based on the Brawley-Calipatria weather station dataset (1982-2004).

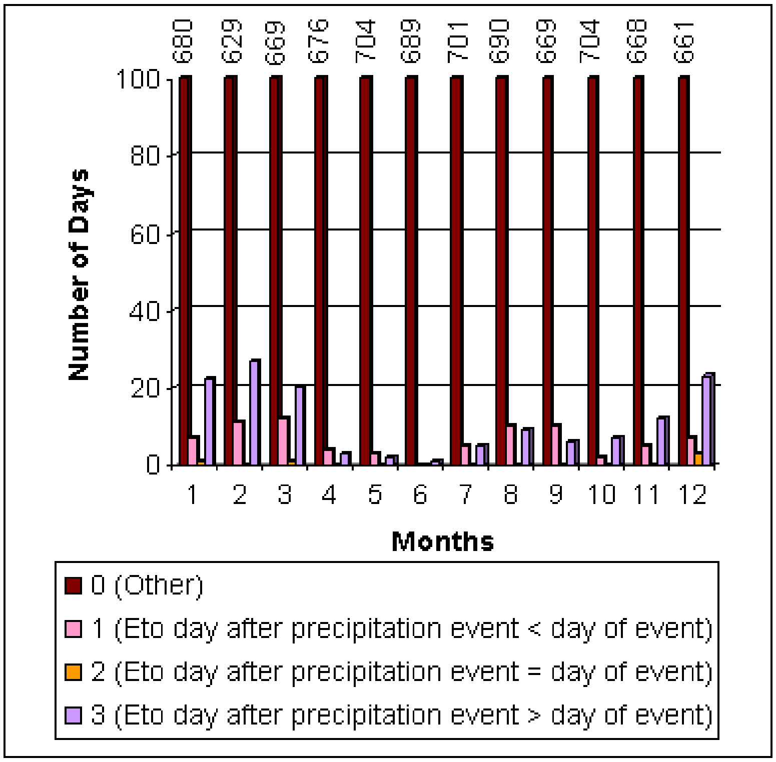


Fig. A.64 - Analysis of the variables ‘Month’ and ‘EtoTwo’ based on the Brawley-Calipatria weather station dataset (1982-2004).

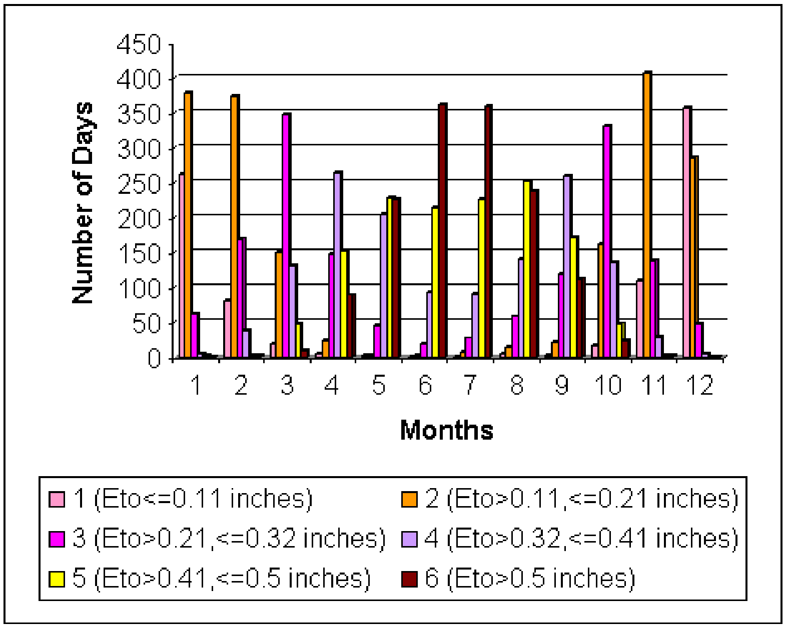


Fig. A.65 - Analysis of the variables ‘Month’ and ‘EtoAmt’ based on the Brawley-Calipatria weather station dataset (1982-2004).

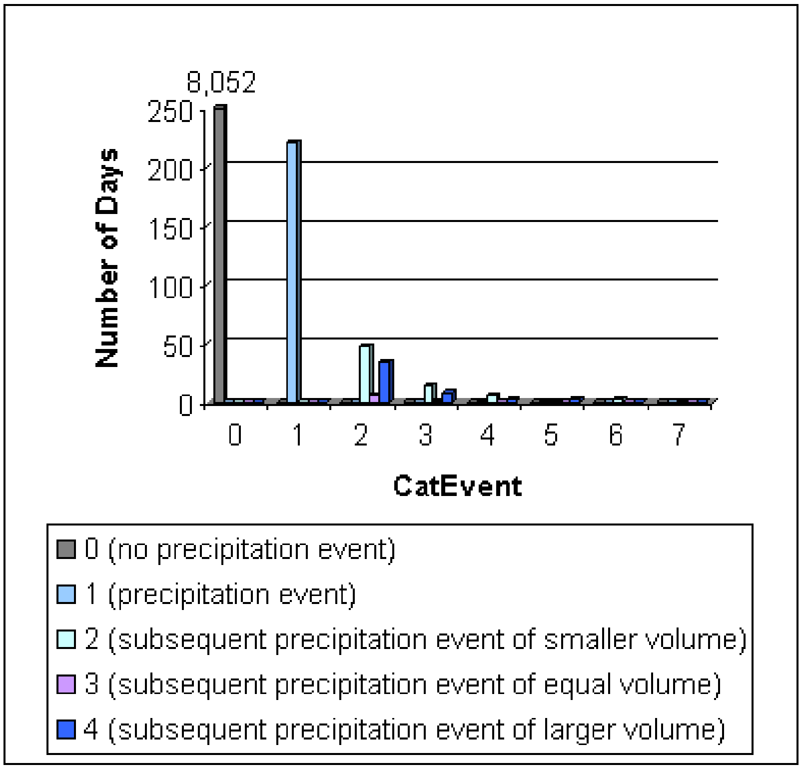


Fig. A.66 - Analysis of the variables ‘CatEvent’ and ‘CatVol’ based on the Brawley-Calipatria weather station dataset (1982-2004).

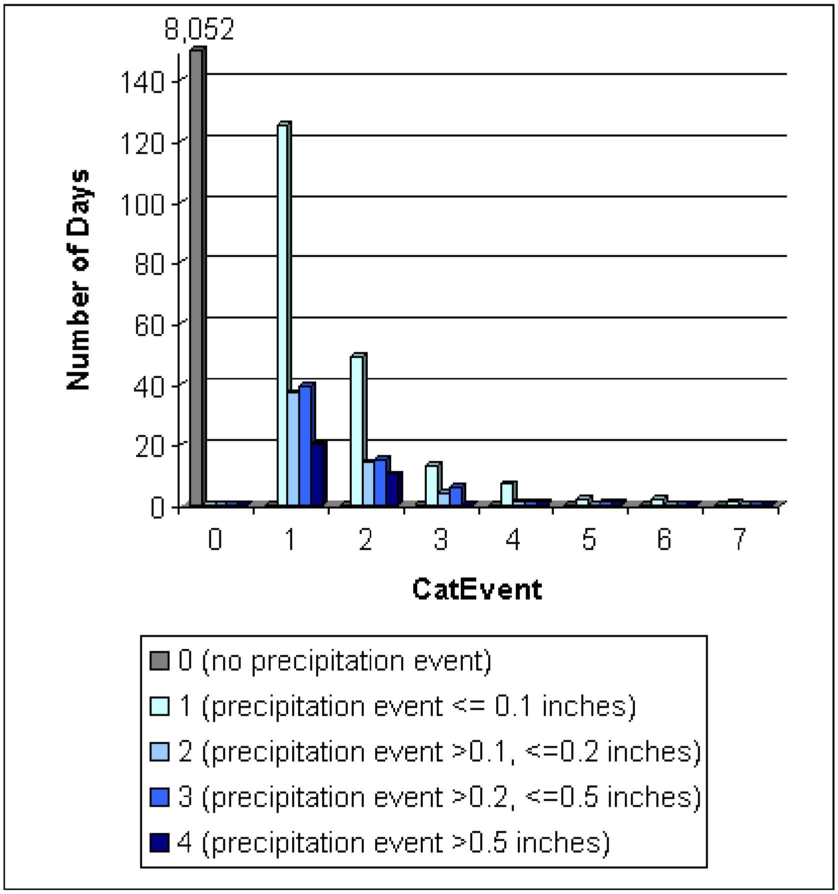
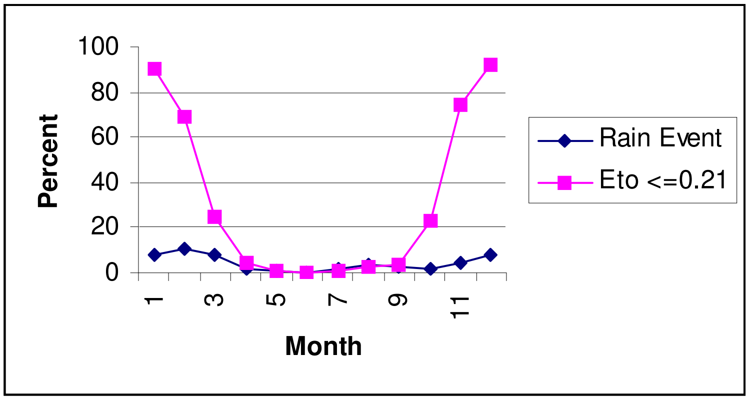


Fig. A.67 - Analysis of the variables ‘CatEvent’ and ‘PrcpAmt’ based on the Brawley-Calipatria weather station dataset (1982-2004).



Rain Event = Percent of observations having some amount of precipitation, i.e. precipitation event.

Eto <=0.21 = Percent of observations having an evapotranspiration ≤ 0.21 inches.

Fig. A.68 - Monthly comparison of precipitation event days and days having Eto ≤ 0.21 inches based on the Brawley-Calipatria weather station dataset (1982-2004).

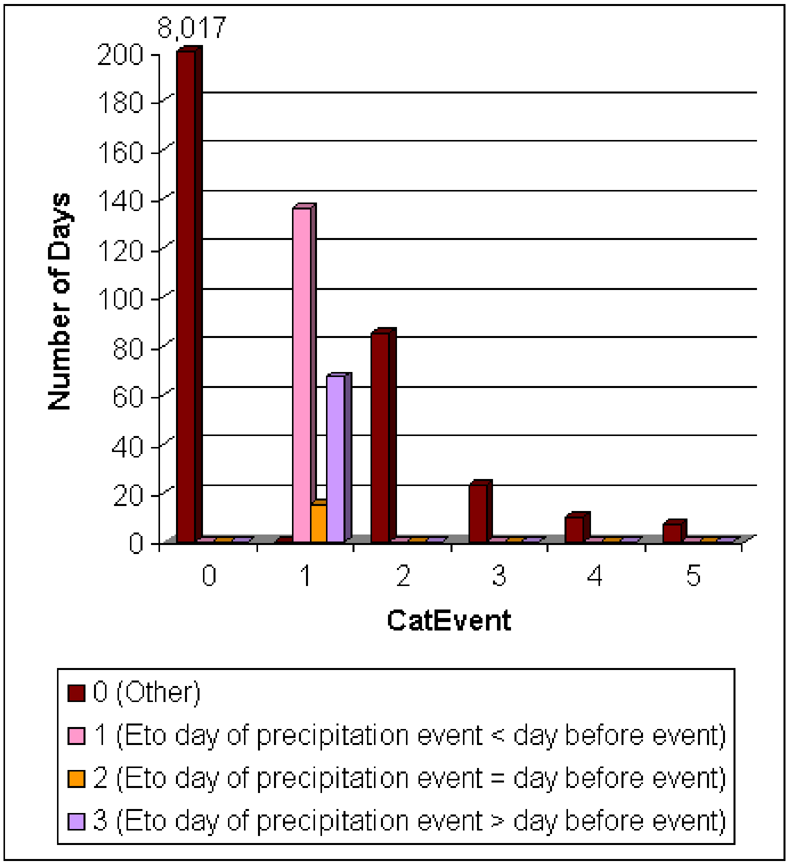


Fig. A.69 - Analysis of the variables 'CatEvent' and 'EtoFirst' based on the Brawley-Calipatria weather station dataset (1982-2004).

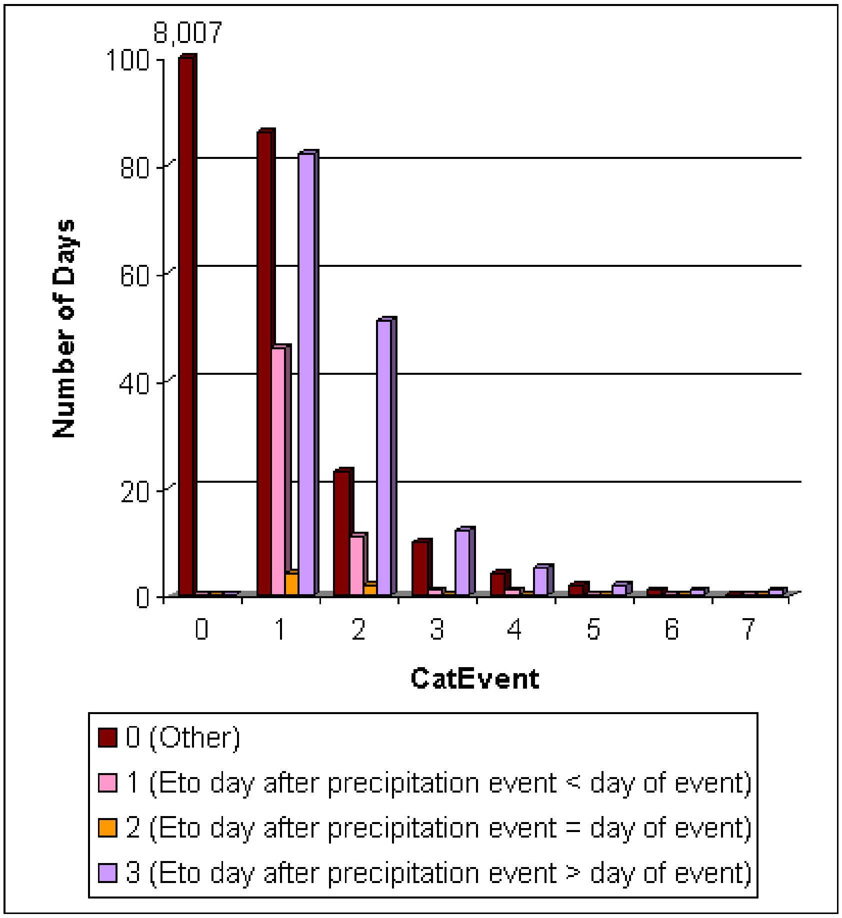


Fig. A.70 - Analysis of the variables ‘CatEvent’ and ‘Etolev2’ based on the Brawley-Calipatria weather station dataset (1982-2004).

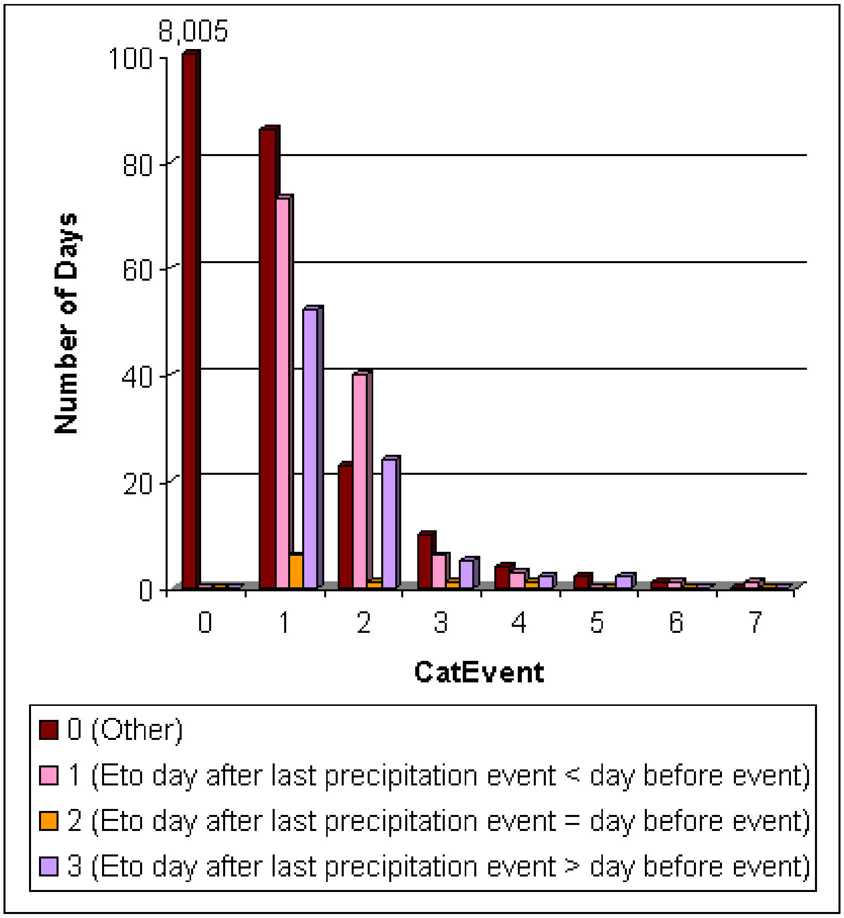


Fig. A.71 - Analysis of the variables ‘CatEvent’ and ‘EtoOne’ based on the Brawley-Calipatria weather station dataset (1982-2004).

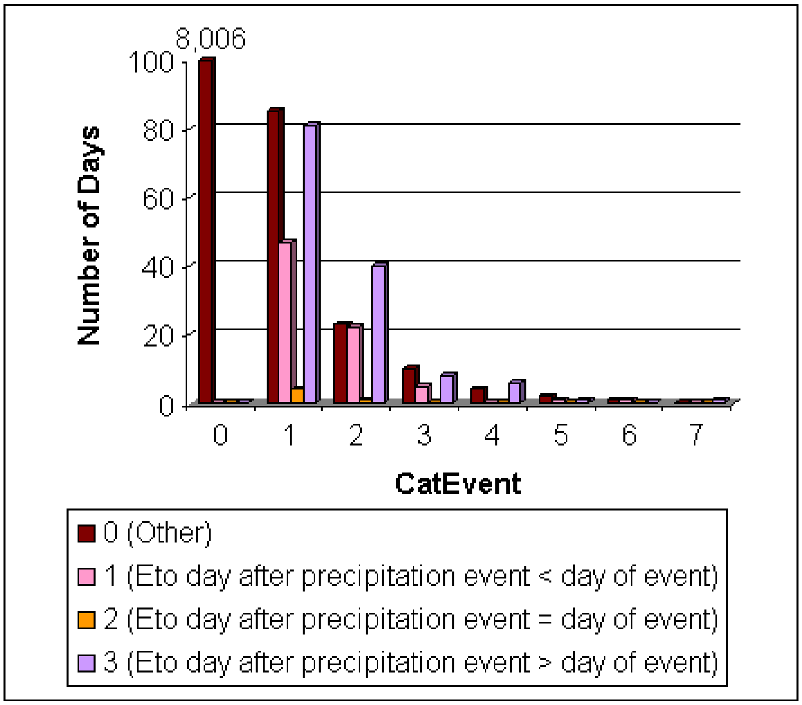


Fig. A.72 - Analysis of the variables ‘CatEvent’ and ‘EtoTwo’ based on the Brawley-Calipatria weather station dataset (1982-2004).

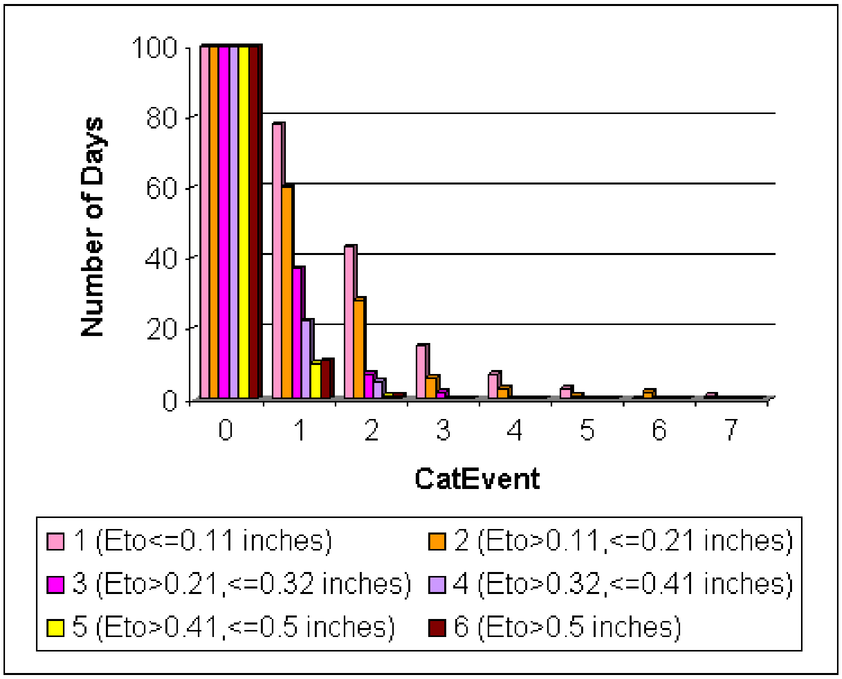


Fig. A.73 - Analysis of the variables ‘CatEvent’ and ‘EtoAmt’ based on the Brawley-Calipatria weather station dataset (1982-2004).

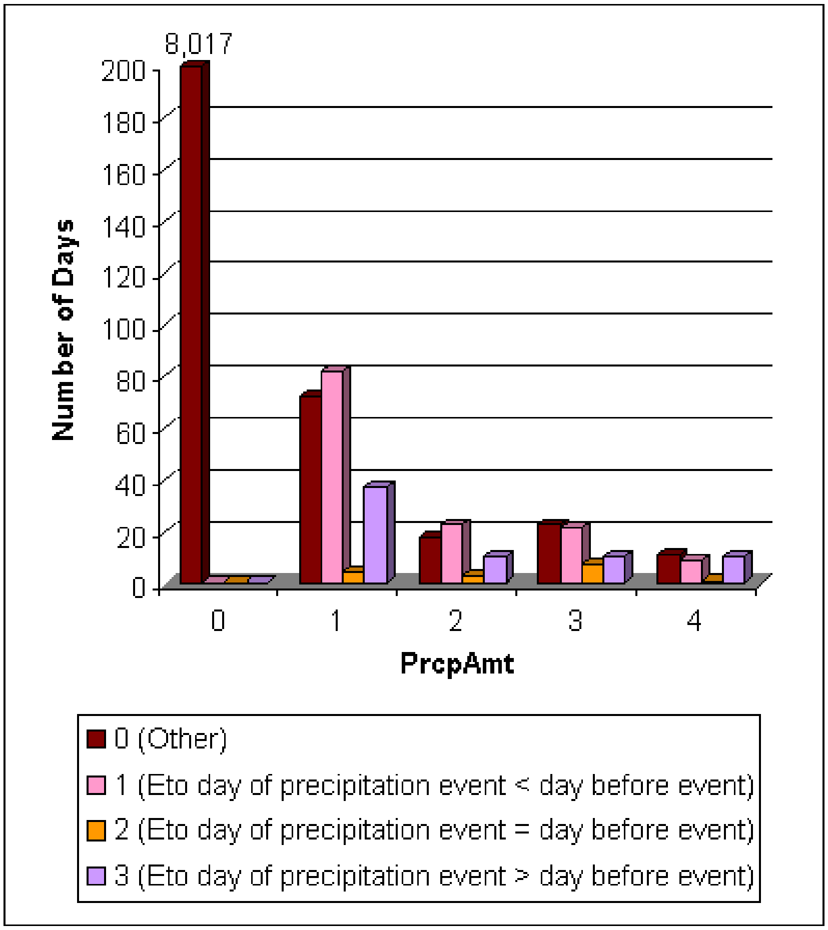


Fig. A.74 - Analysis of the variables 'PrcpAmt' and 'EtoFirst' based on the Brawley-Calipatria weather station dataset (1982-2004).

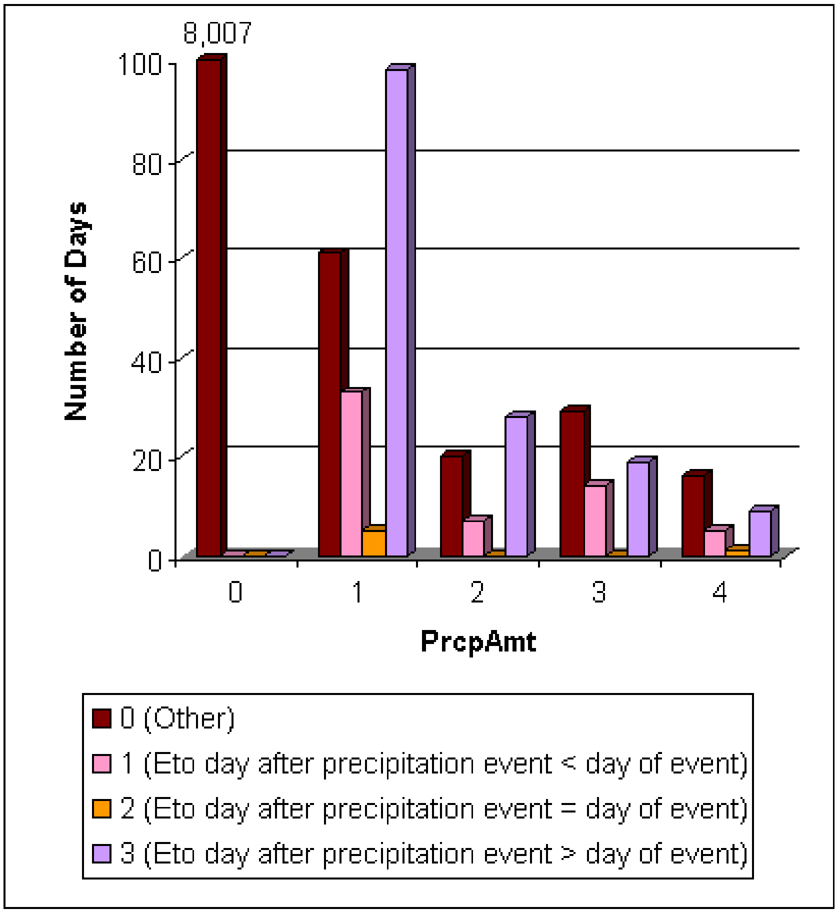


Fig. A.75 - Analysis of the variables 'PrcpAmt' and 'Etolev2' based on the Brawley-Calipatria weather station dataset (1982-2004).

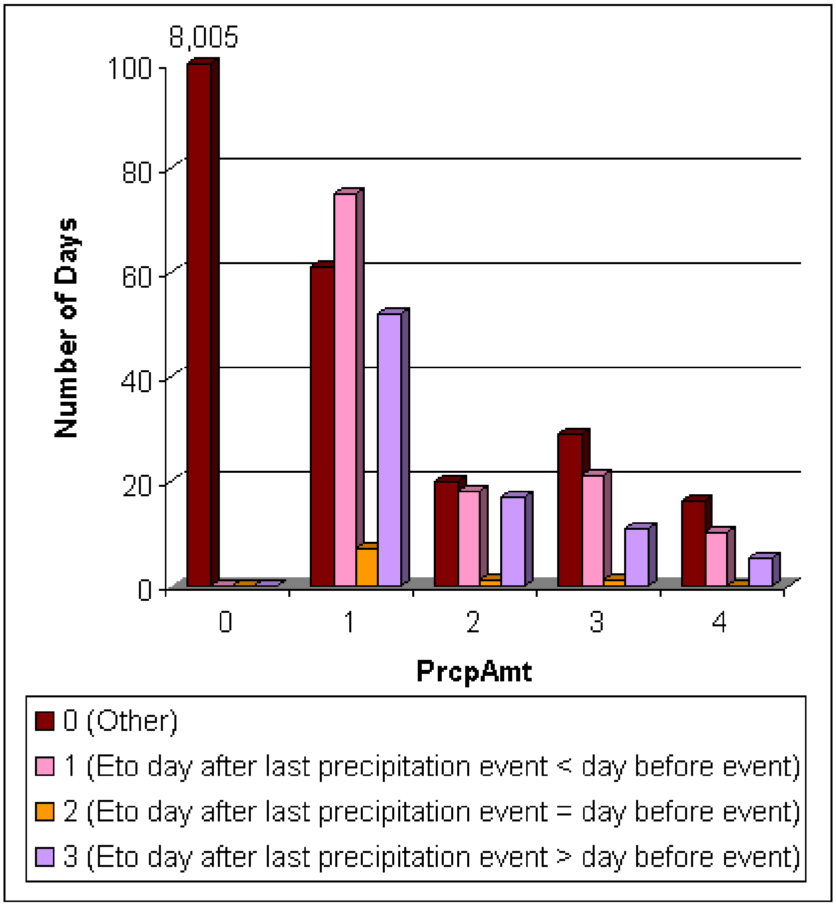


Fig. A.76 - Analysis of the variables ‘PrcpAmt’ and ‘EtoOne’ based on the Brawley-Calipatria weather station dataset (1982-2004).

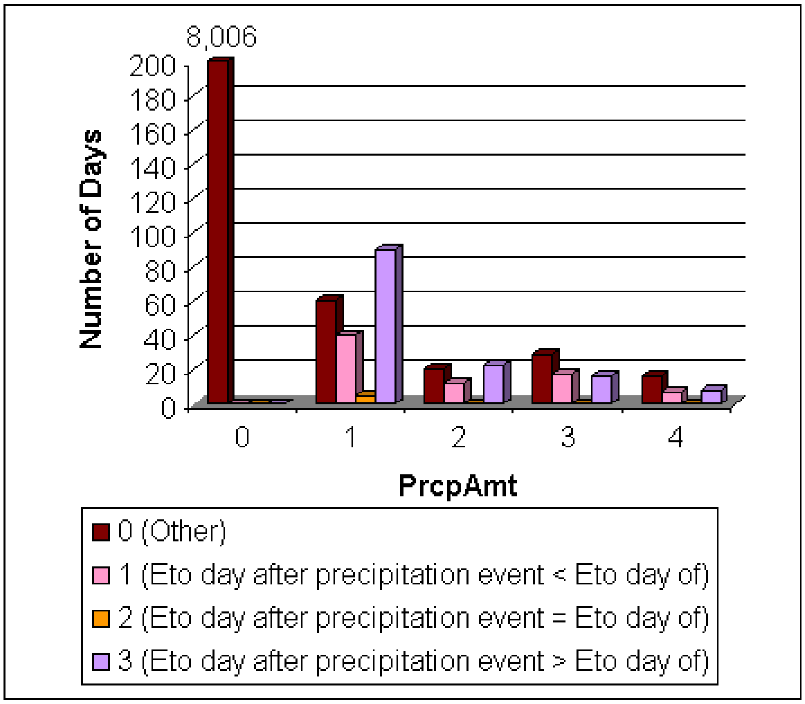


Fig. A.77 - Analysis of the variables ‘PrcpAmt’ and ‘EtoTwo’ based on the Brawley-Calipatria weather station dataset (1982-2004).

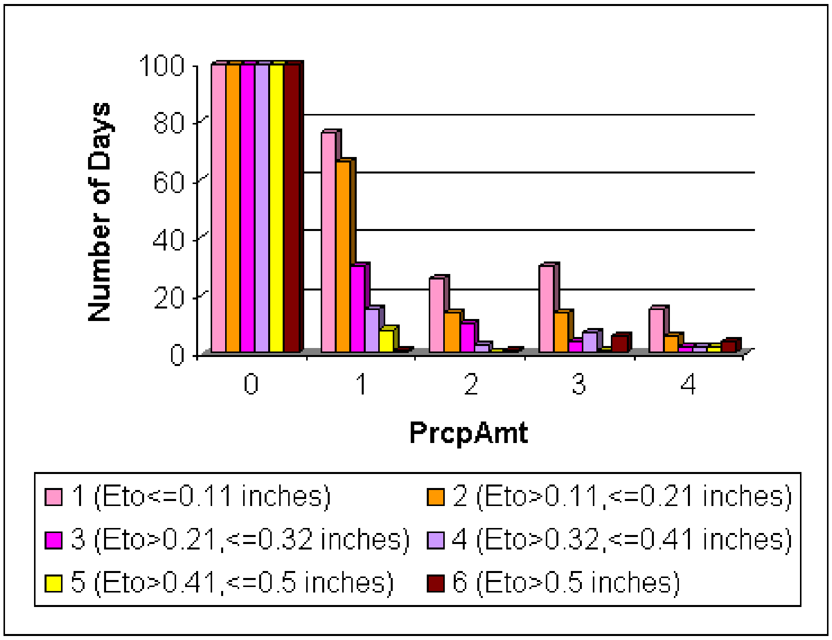


Fig. A.78 - Analysis of the variables ‘PrcpAmt’ and ‘EtoAmt’ based on the Brawley-Calipatria weather station dataset (1982-2004).

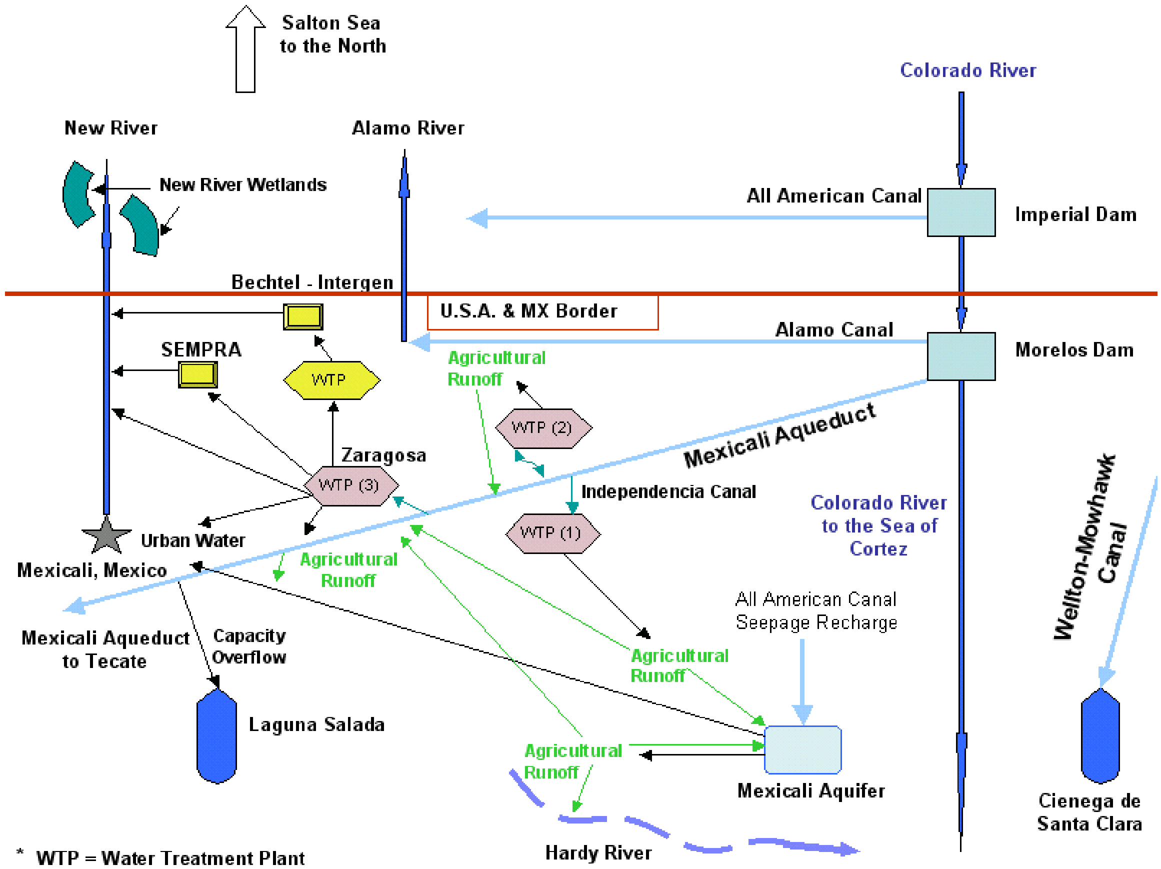
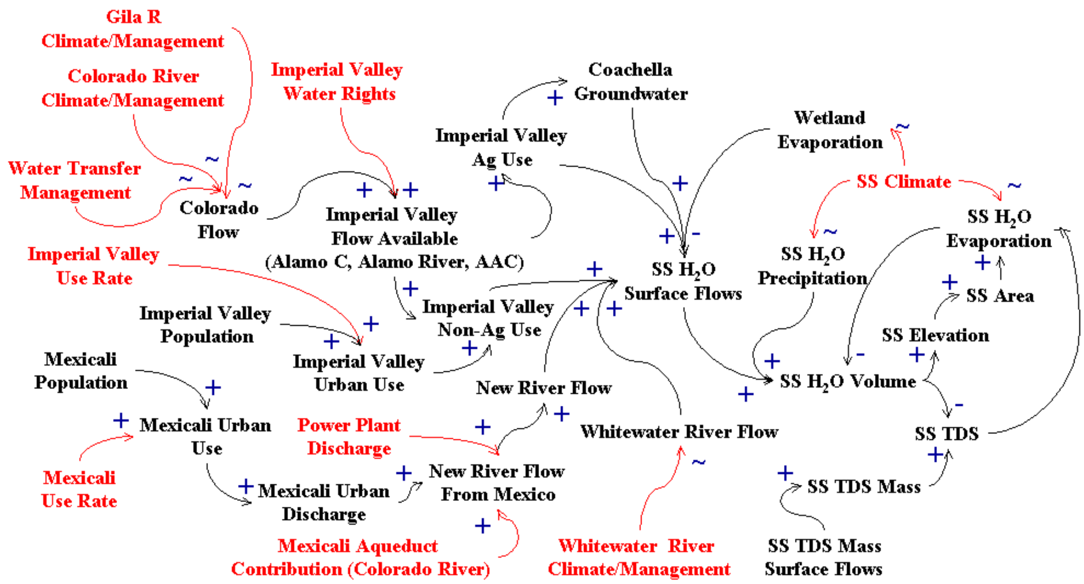


Fig. A.79 - Diagram of the Lower Colorado River Basin water flows and water quality dynamics south of the Salton Sea and within Mexico.



*Positive impact is denoted by a +, negative impact is denoted by a -, and either + or - is denoted by ~
** Abbreviations: Imp = Imperial, IV = Imperial Valley, R = River, SS = Salton Sea, TDS = Total Dissolved Solids, H_2O = Water, Alamo C, AAC = Alamo Canal and All American Canal, Brine Ex = Brine Extraction, Elev = Elevation, Precip = Precipitation, Ag = Agricultural, non-Ag = non-agricultural, Vol = Volume, Manag = Management

Fig. A.80 - Model schematic of the Lower Colorado River Basin water volume and water quality sectors.

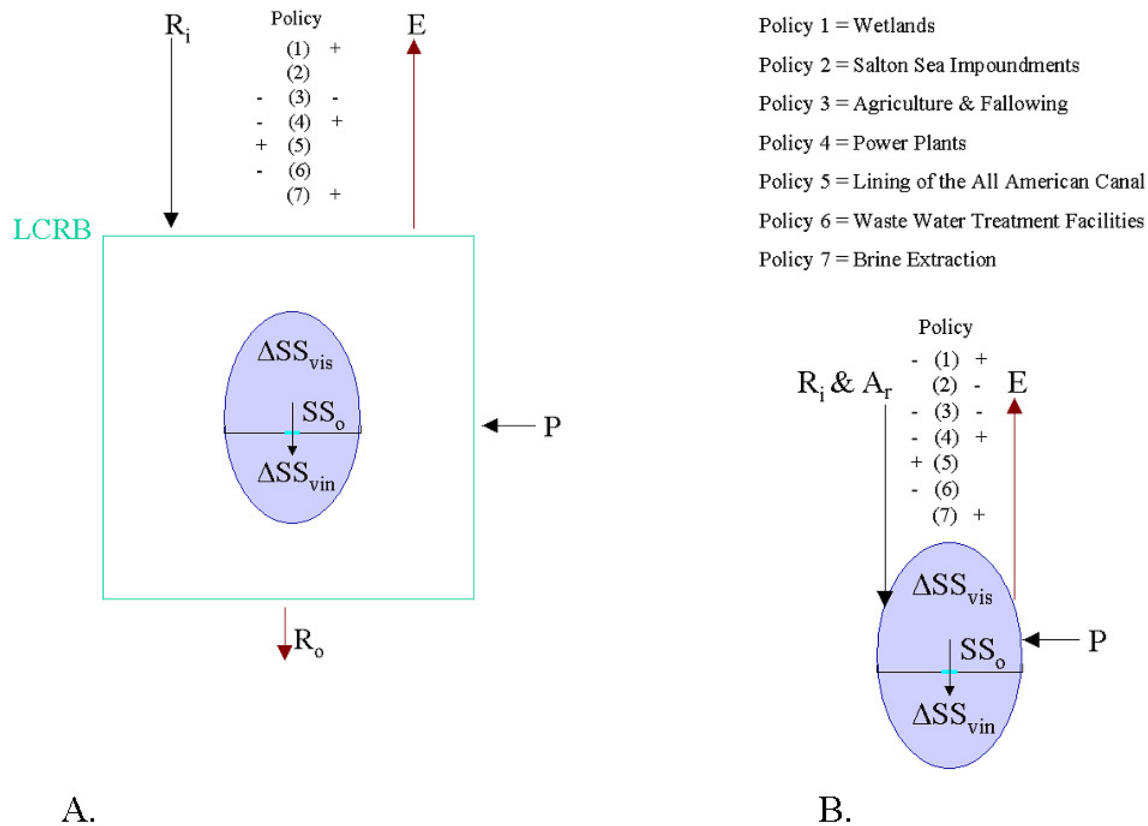
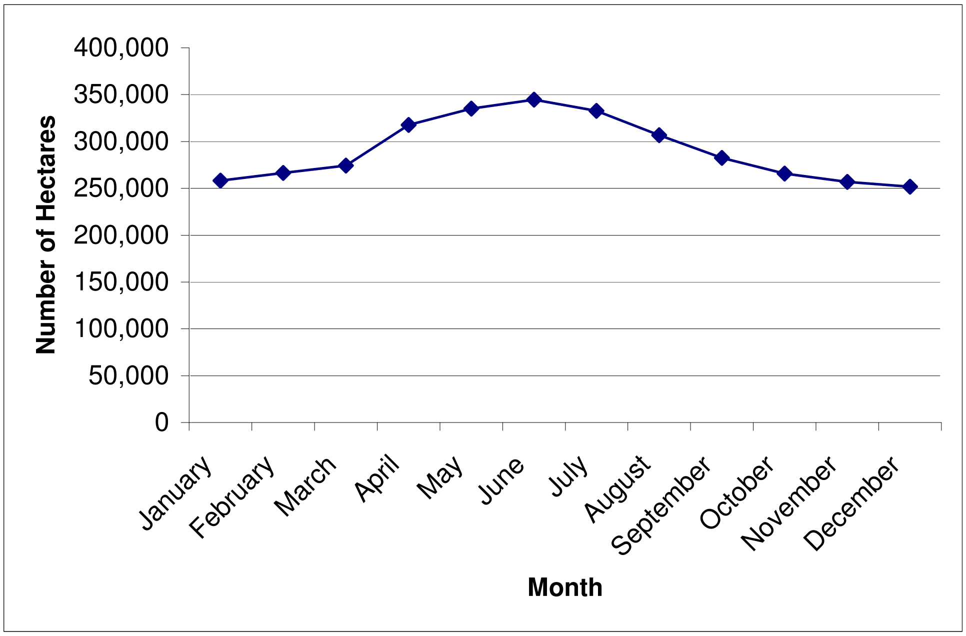
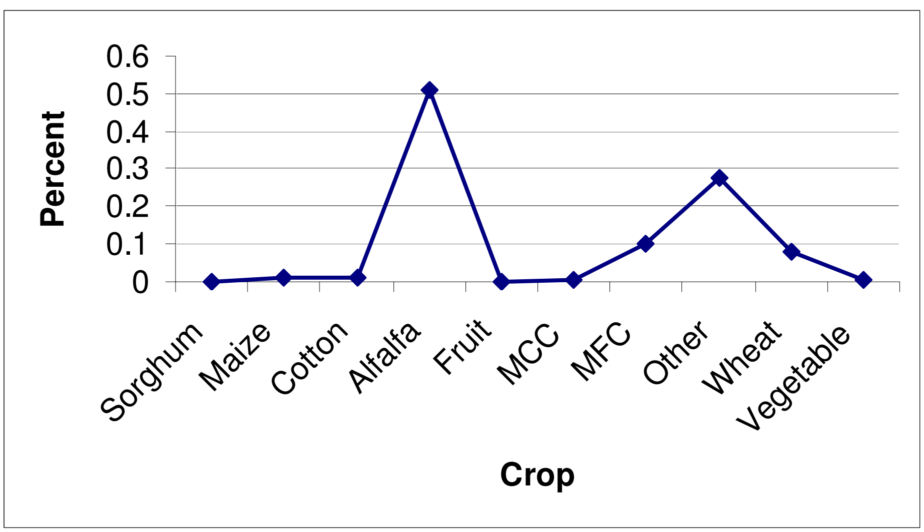


Fig. A.81 - Lower Colorado River Basin (LCRB) precipitation (P) and river outflows (R_o), changes in stabilized and non-stabilized sea impoundment water volumes, (ΔSS_{vis} and ΔSS_{vin}, respectively), outflow from one impoundment to the other (SS_o), and Salton Sea mass balance and implications (+ or -) of policies on evaporation (E), river inflows (R_i) and agricultural runoff (A_r).



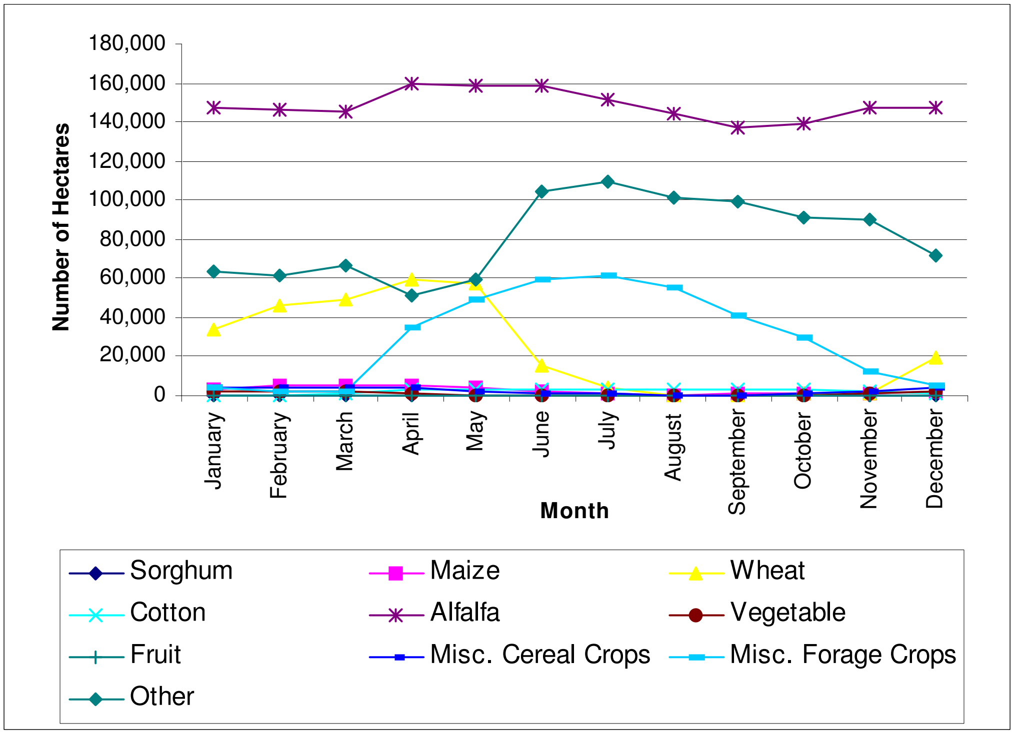
* Data source: Imperial Irrigation District Water Department (2004)

Fig. A.82 - Crop hectarage in the Imperial Valley by month.



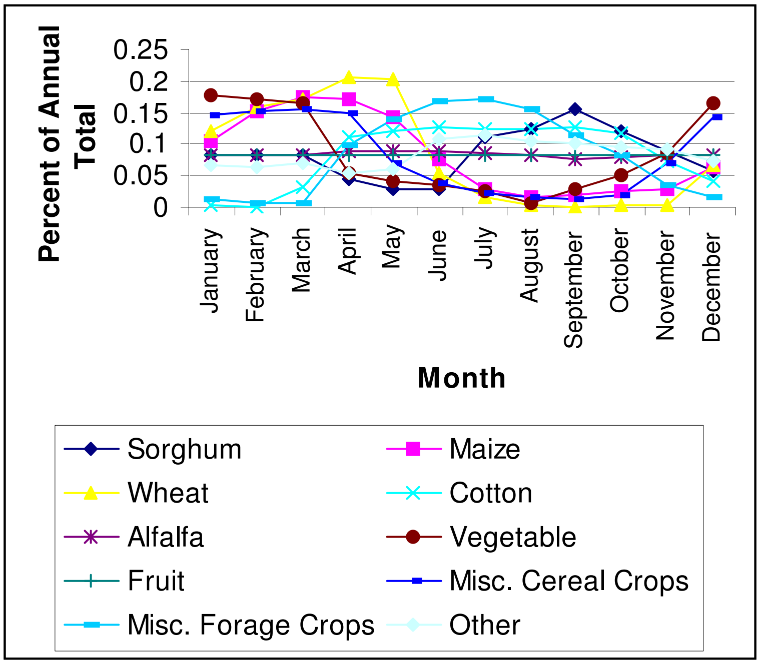
* Data source: Imperial Irrigation District Water Department (2004)

Fig. A.83 - Percent of annual total acreage for a given crop type in Imperial Valley based on 2003 data from Imperial Irrigation District Water Department (IIDWD).



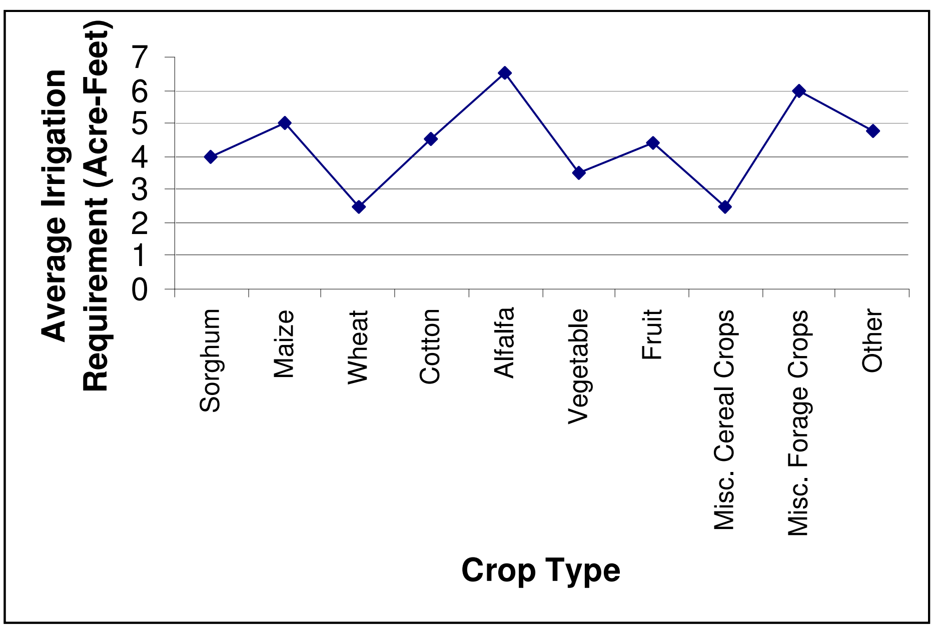
* Data source: Imperial Irrigation District Water Department (2004)

Fig. A.84 - Monthly crop hectarage by crop type in the Imperial Valley.



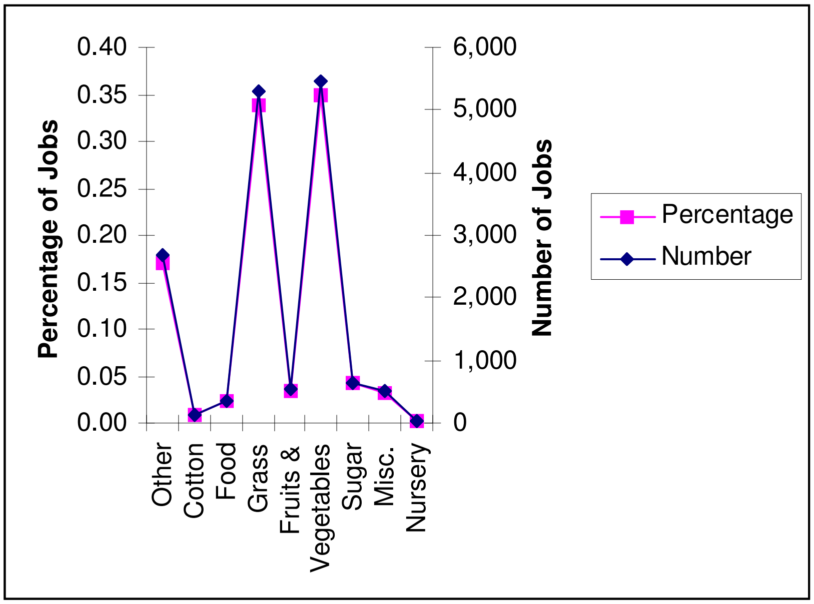
* Data source: Imperial Irrigation District Water Department (2004)

Fig. A.85 - Monthly proportions of annual crop hectarages in the Imperial Valley.



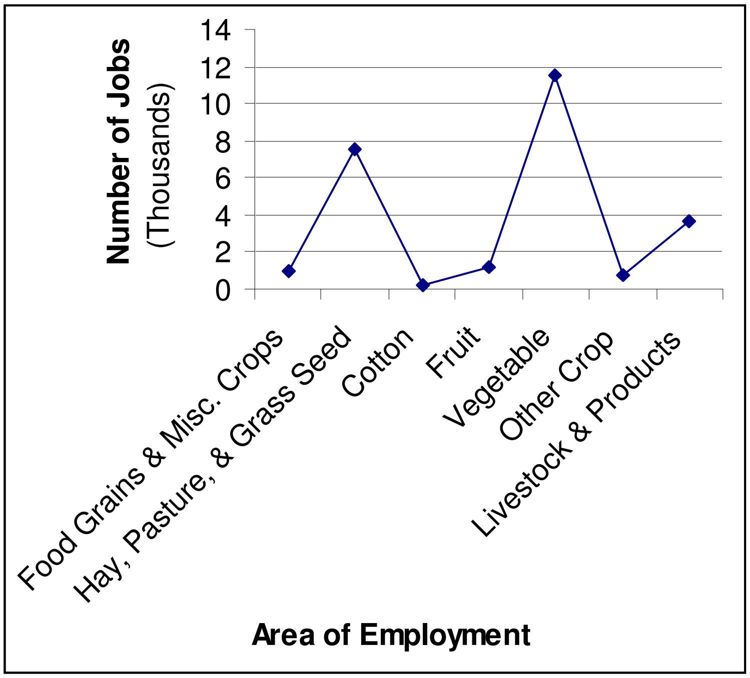
* Data source: Bottoms (2006) and Howitt et al. (1999)

Fig. A.86 - Imperial Valley average water requirements for crop types.



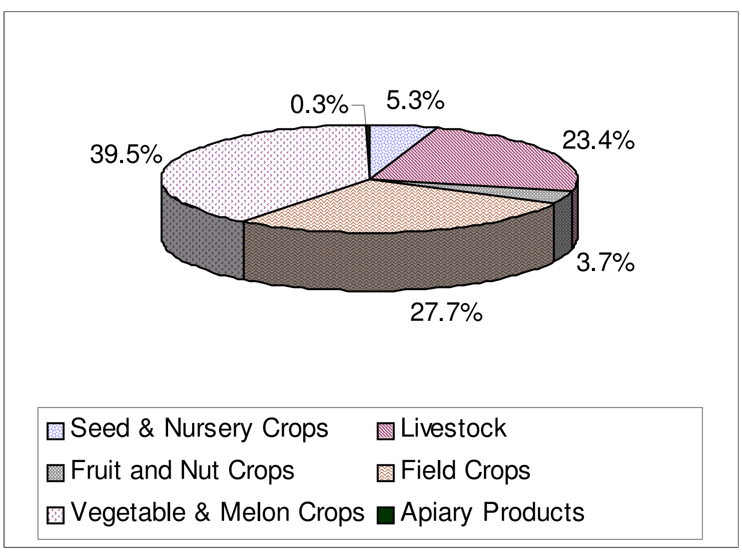
* Data source: Based on Ritter (2001)

Fig. A.87 - Economic impacts of agricultural production areas in Imperial County for the year 2000.



* Data source: Based on Ritter (2001)

Fig. A.88 - Areas of agricultural employment in Imperial County for the year 2000 aggregated for the Salton Sea model.



* Data source: Based on Ritter (2001)

Fig. A.89 - Proportions of the gross value of major areas of agricultural production in Imperial County for the year 2000.

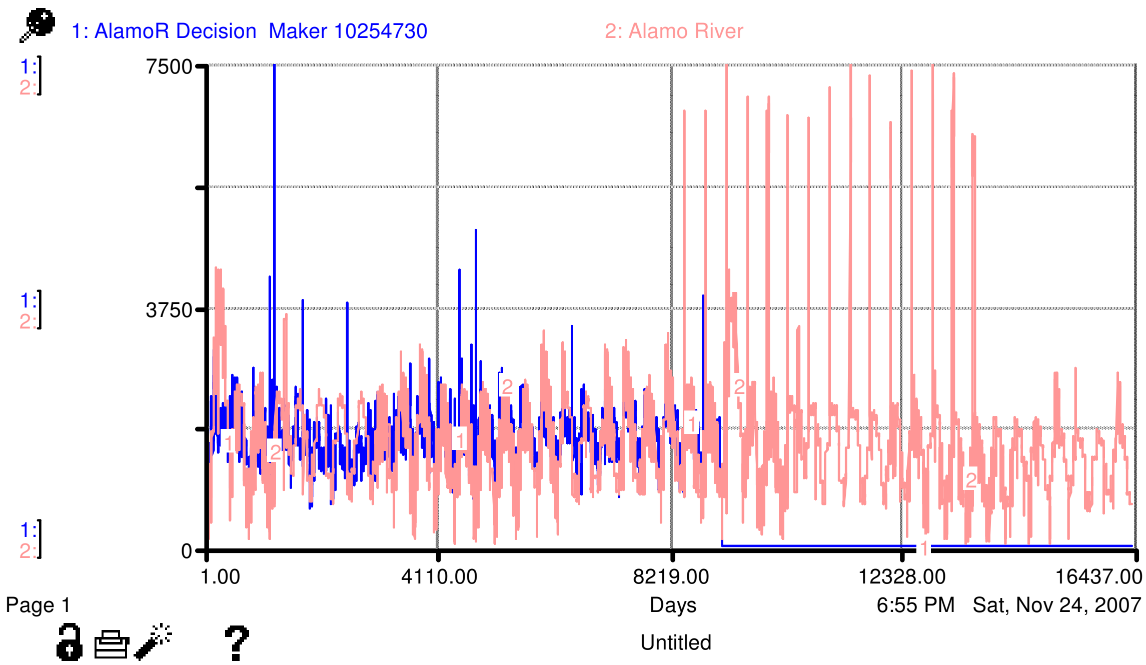


Fig. A.90 - Alamo River daily flow (acre-feet) – historic data (USGS gage station 10254730) (1) versus simulated (2).

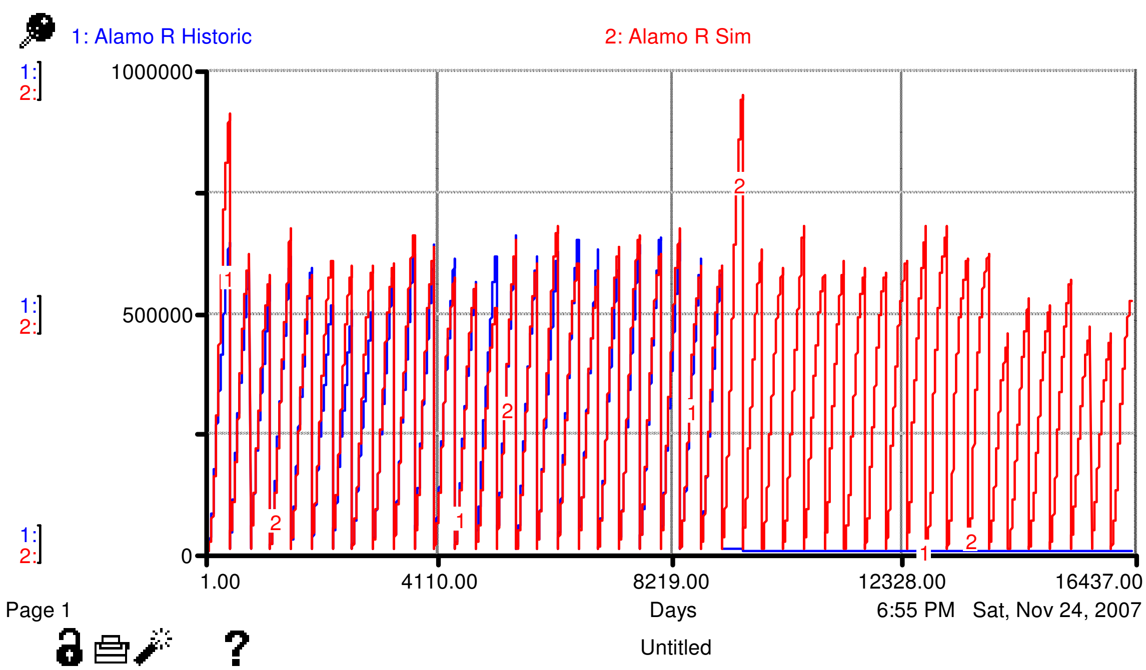


Fig. A.91 - Alamo River total annual accumulated inflows (acre-feet) observed on a daily timestep – historic (1) versus simulated (2).

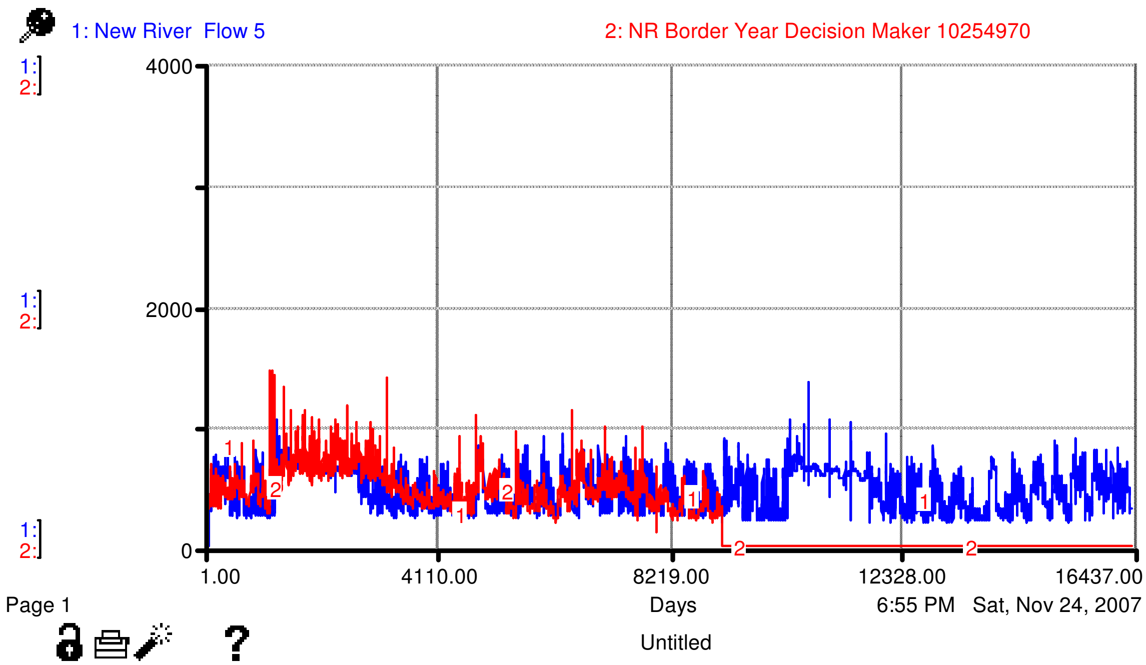


Fig. A.92 - New River at U.S.-Mexico border daily flow (acre-feet) – historic data (USGS gage station 10254970) (2) versus simulated (1).

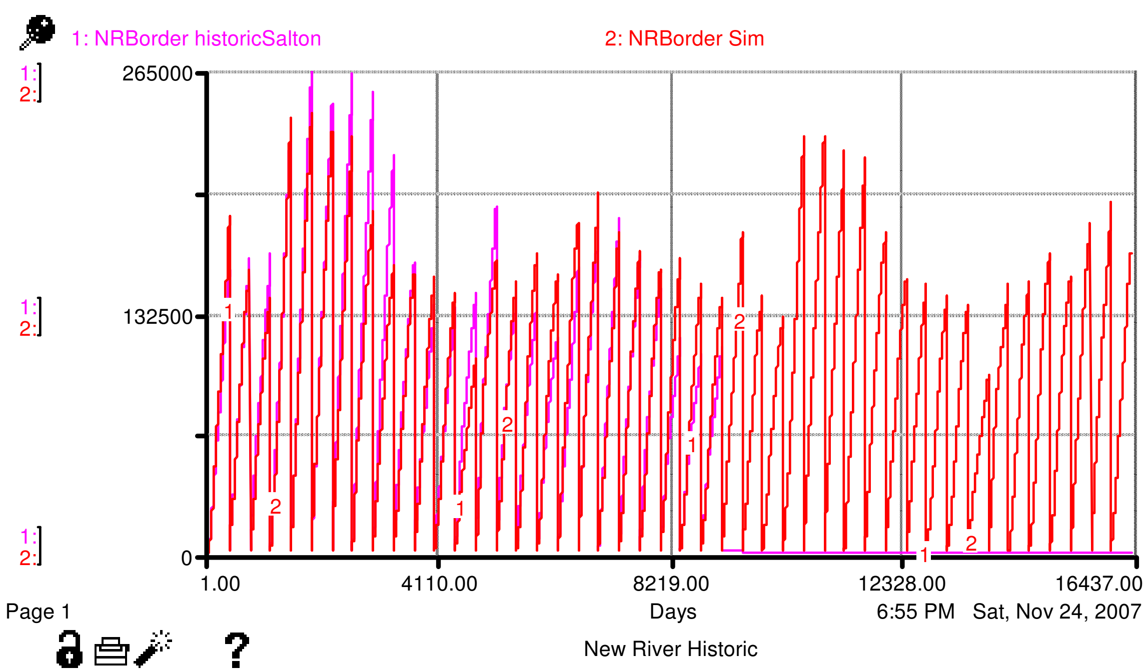


Fig. A.93 - New River total annual accumulated flows to the Salton Sea (acre-feet) observed on a daily timestep – historic (1) (USGS gage station at Westmoreland 10255550) versus simulated (2).

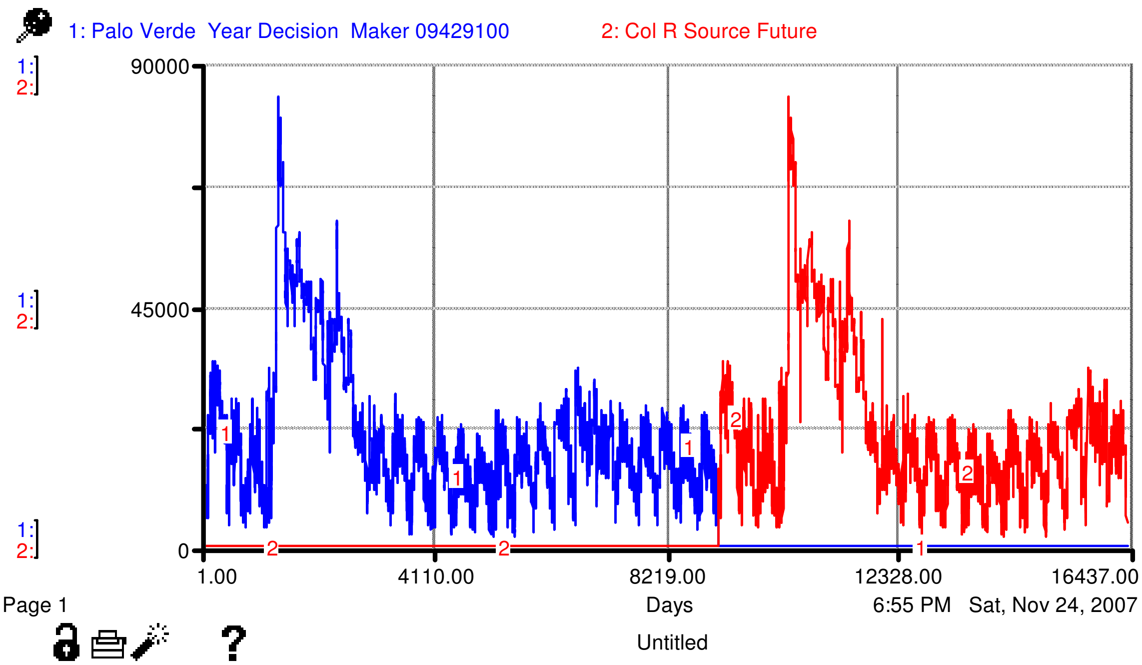


Fig. A.94 - Deterministic Colorado River daily flow (acre-feet) – historic data (USGS gage station 09429100) (1) versus simulated (2).

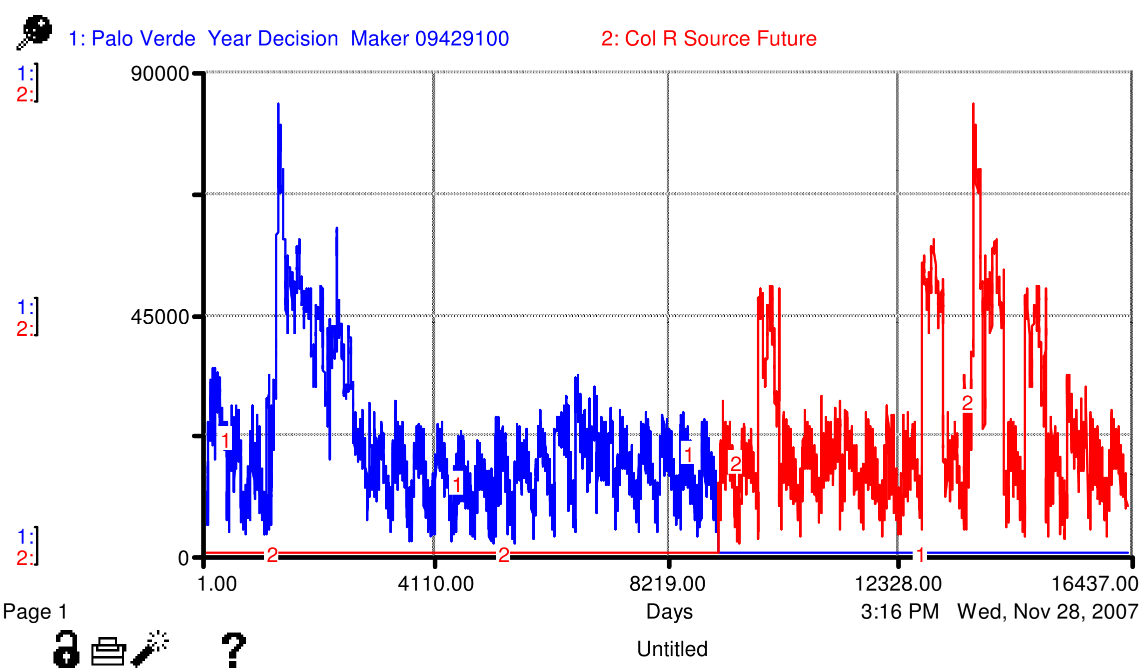


Fig. A.95 - Stochastic Colorado River daily flow (acre-feet) – historic data (USGS gage station 09429100) (1) versus simulated (2).

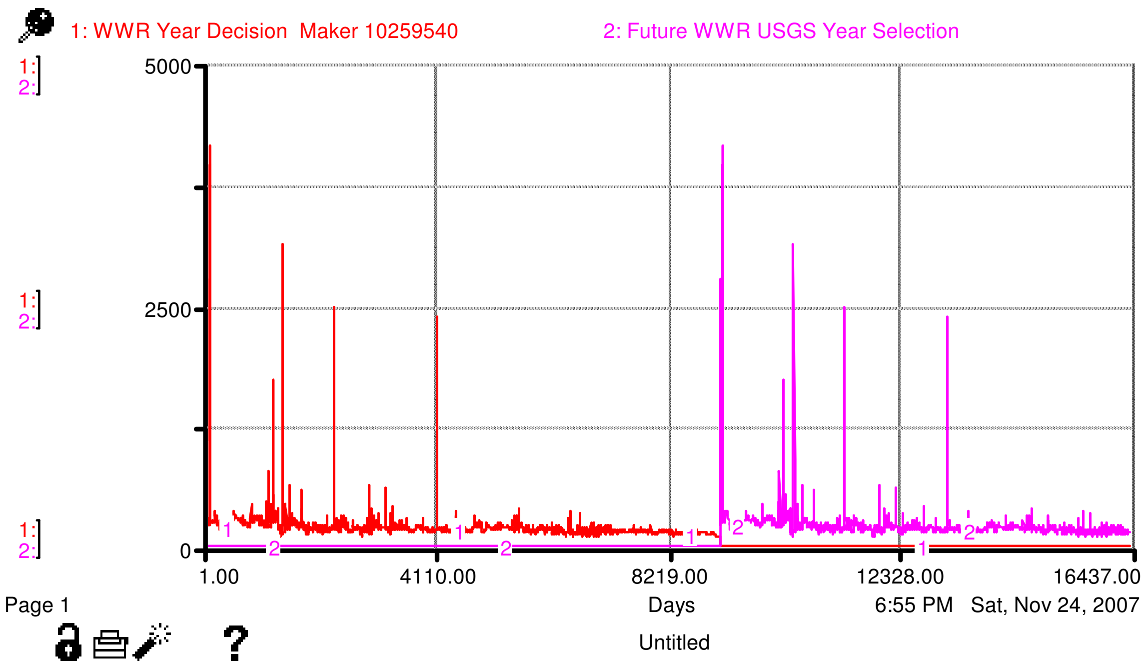


Fig. A.96 - Deterministic Whitewater River daily flow (acre-feet) – historic data (USGS gage station 10259540) (1) versus simulated (2).

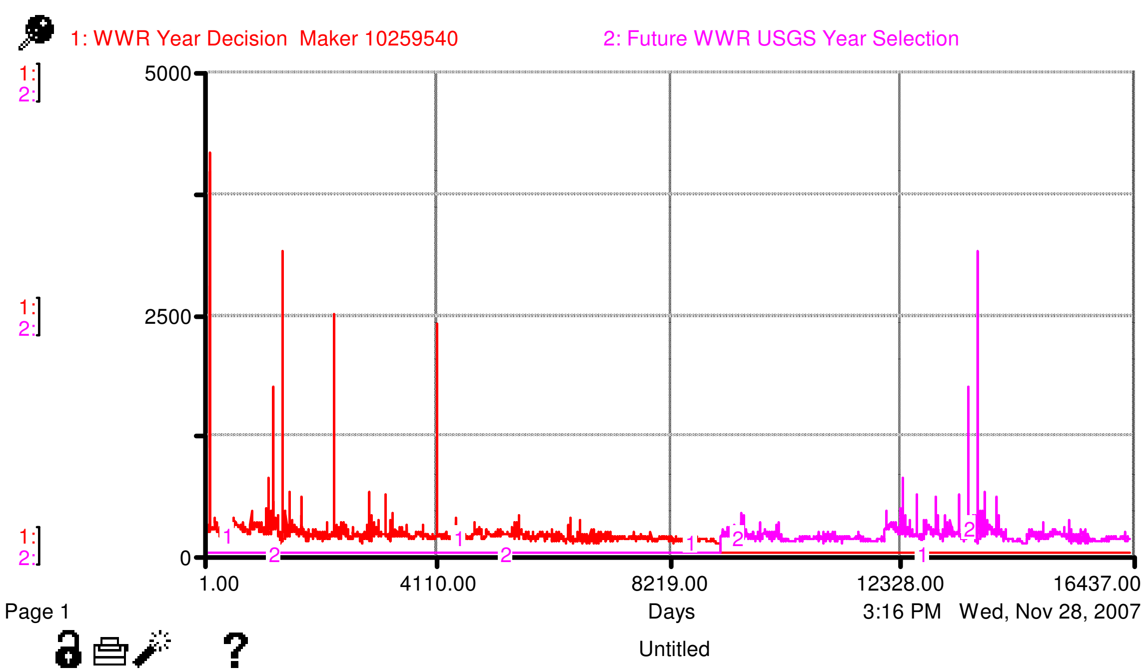


Fig. A.97 - Stochastic Whitewater River daily flow (acre-feet) – historic data (USGS gage station 10259540) (1) versus simulated (2).

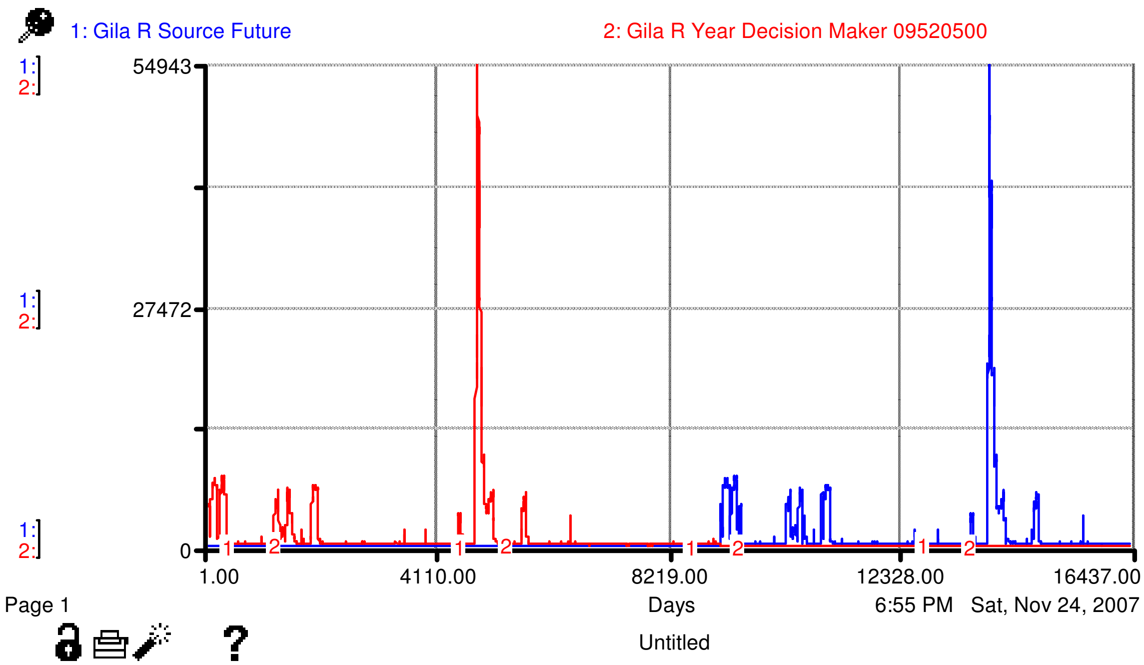


Fig. A.98 - Deterministic Gila River daily flow (acre-feet) – historic data (USGS gage station 09520500) (2) versus simulated (1).

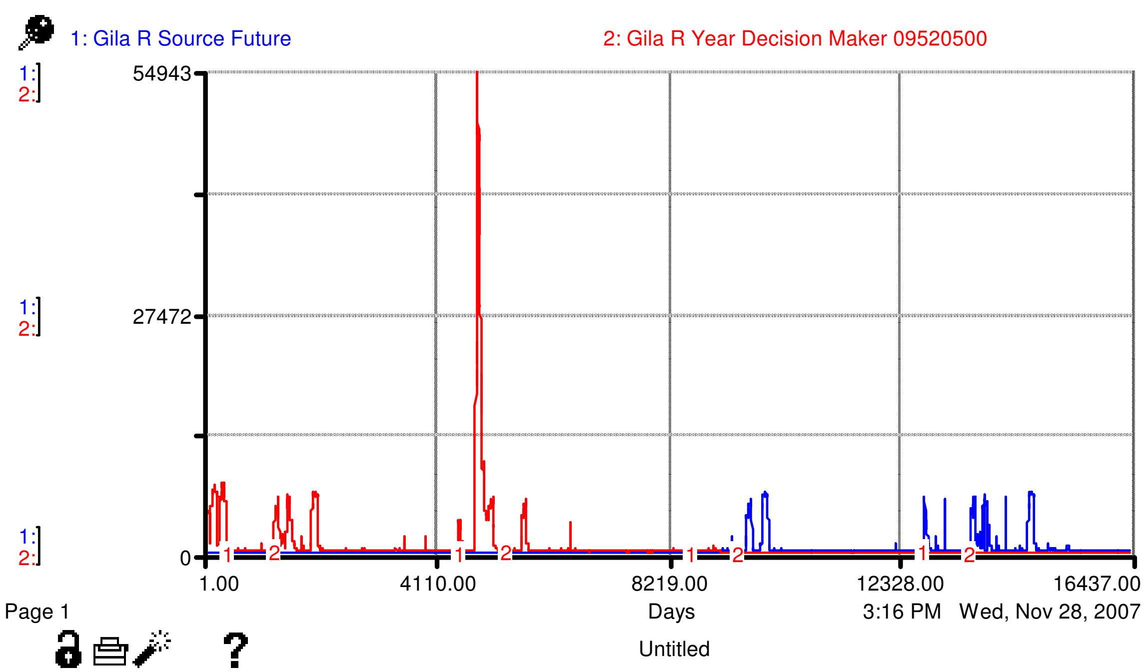


Fig. A.99 - Stochastic Gila River daily flow (acre-feet) – historic data (USGS gage station 09520500) (2) versus simulated (1).

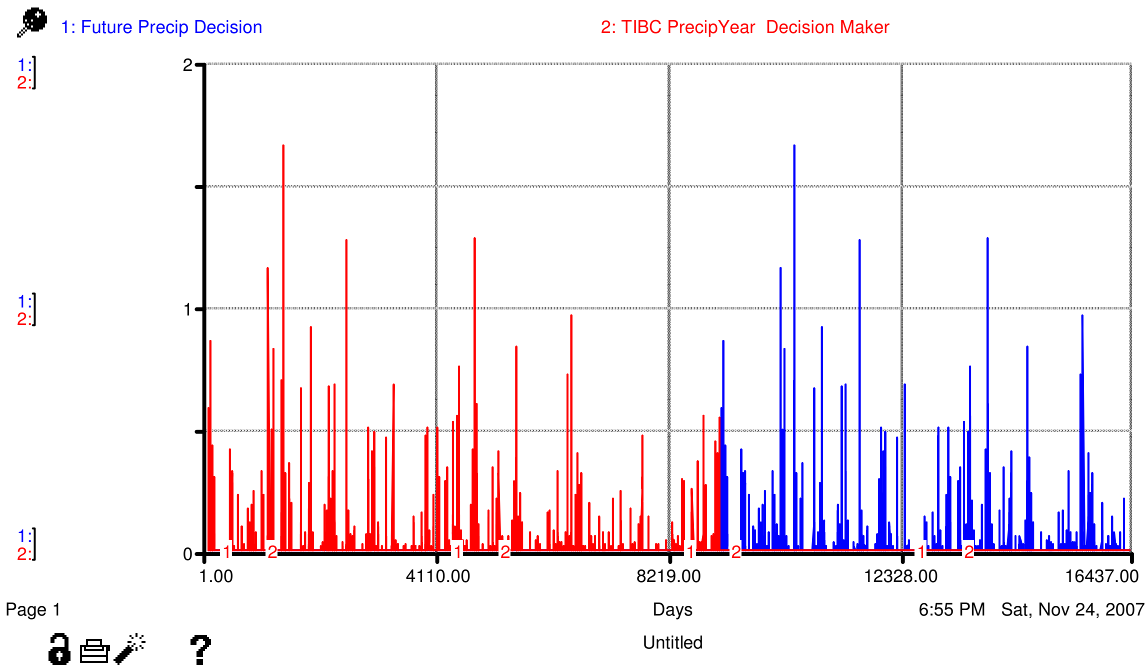


Fig. A.100 - Precipitation events (inches) observed on a daily timestep – historic (2) versus simulated deterministic (1).

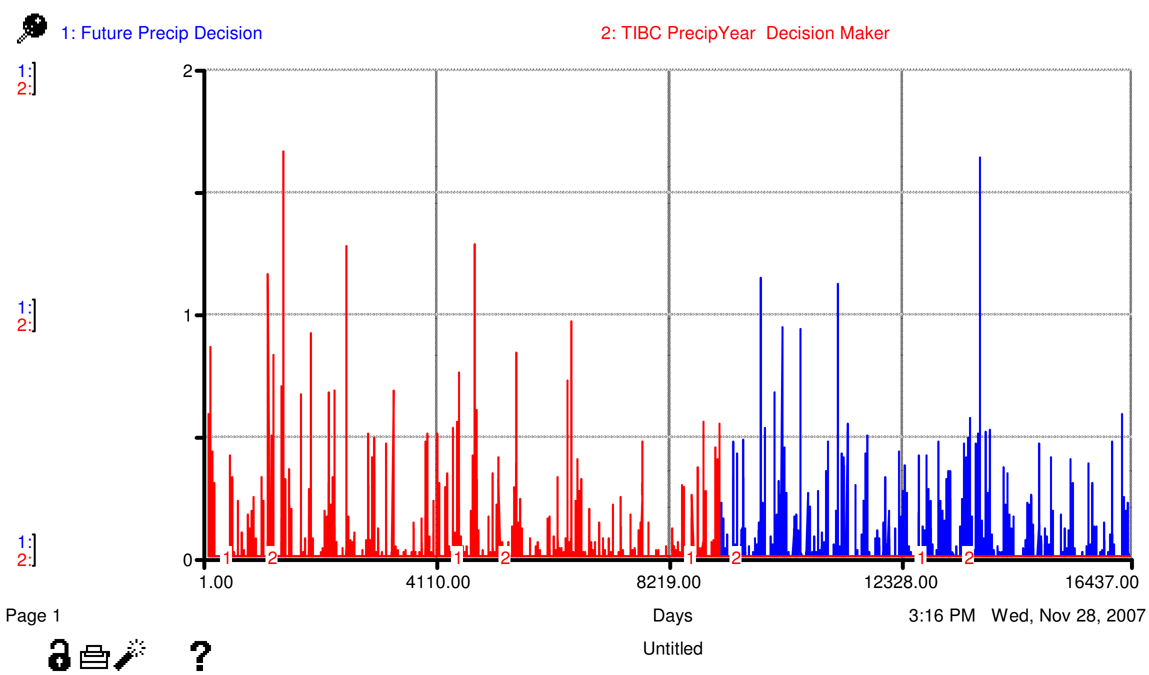


Fig. A.101 - Precipitation events (inches) observed on a daily timestep – historic (2) versus simulated stochastic (1).

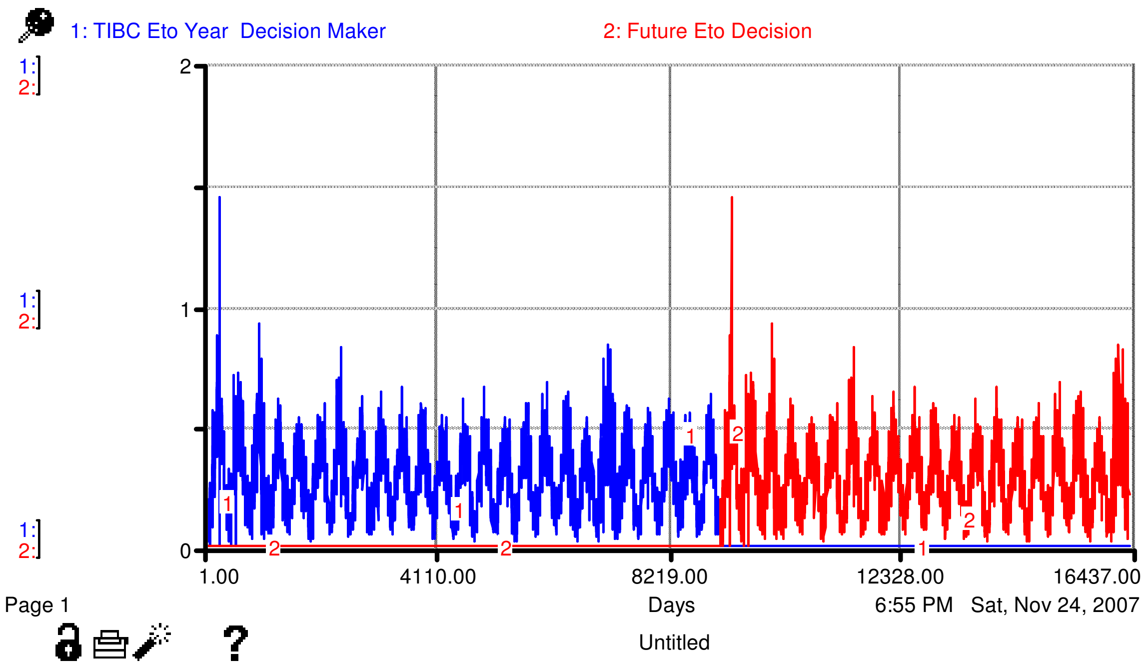


Fig. A.102 - Evapotranspiration events (inches) observed on a daily timestep – historic (1) versus simulated deterministic (2).

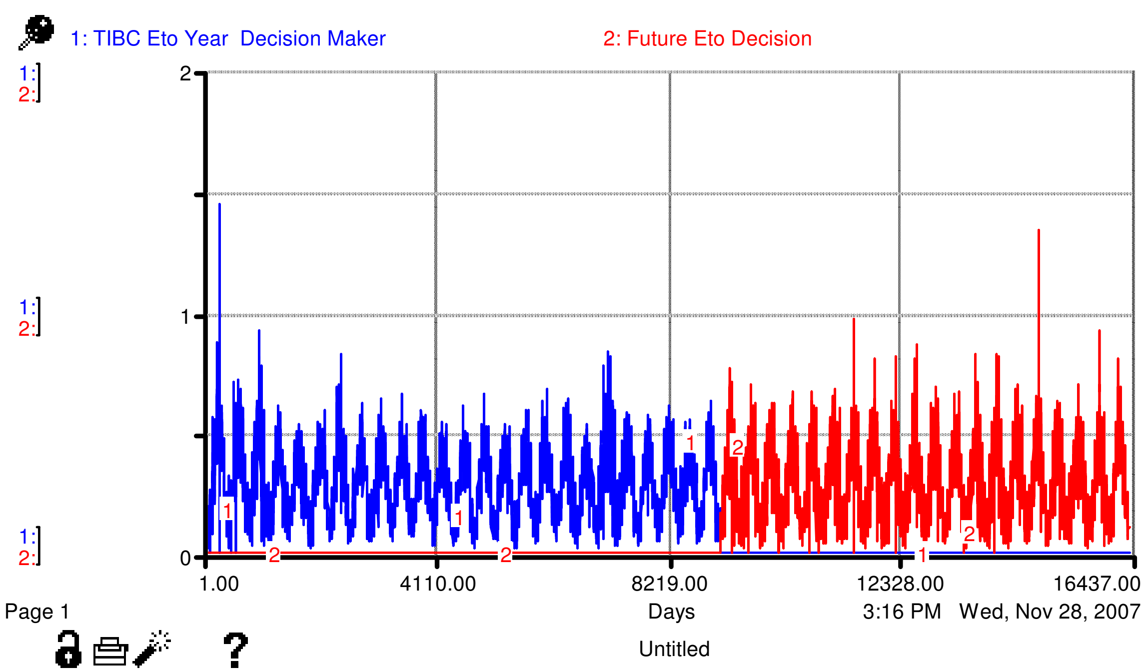


Fig. A.103 - Evapotranspiration events (inches) observed on a daily timestep – historic (1) versus simulated stochastic (2).

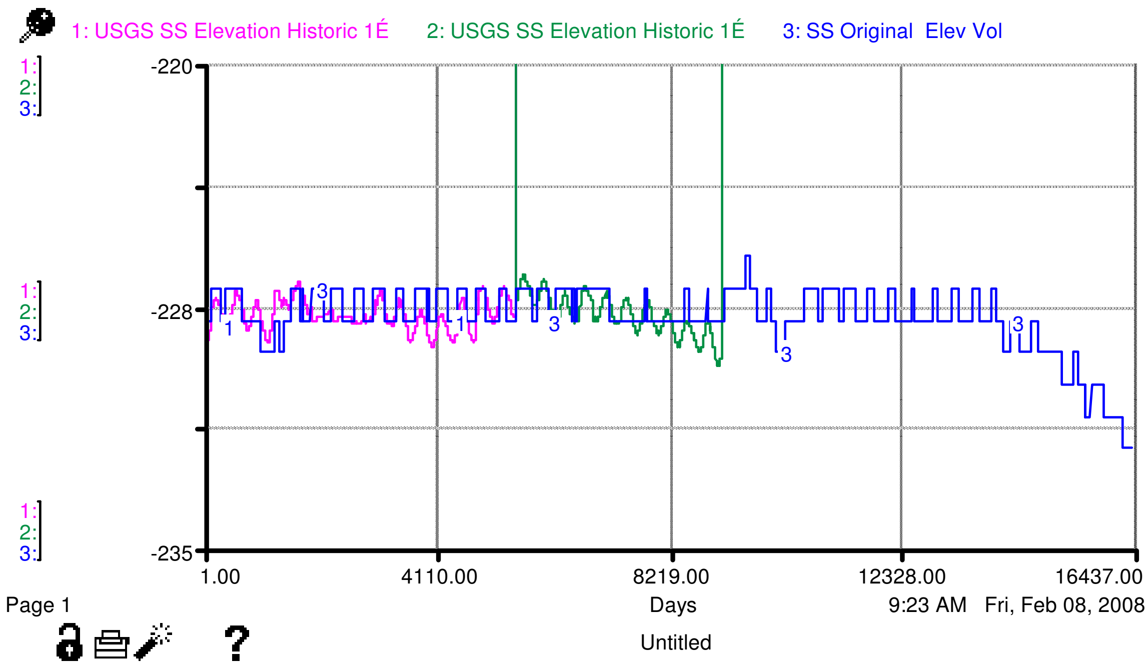


Fig. A.104 - Salton Sea elevation in feet above sea level (fasl) – calibration using USGS daily data over a 15-year period (1980-1994) (1), validation using USGS daily data over a 10-year period (1995-2004) (2), and simulated elevation of the Salton Sea (3).

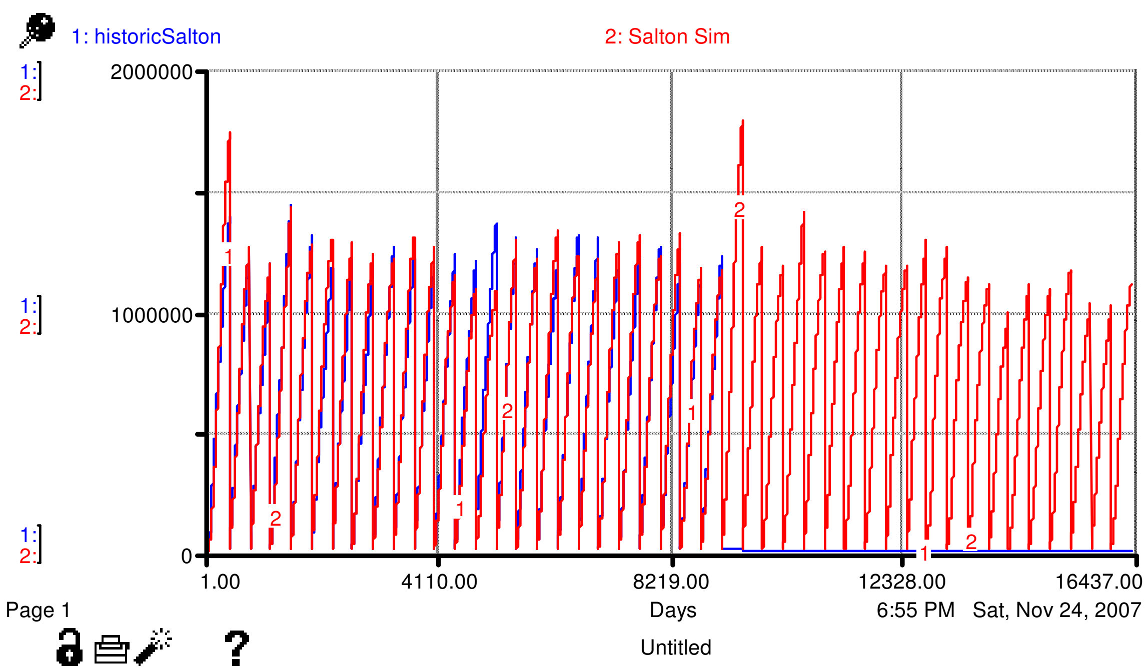


Fig. A.105 - Salton Sea total annual accumulated inflows (acre-feet) observed on a daily timestep – historic (1) versus simulated (2).

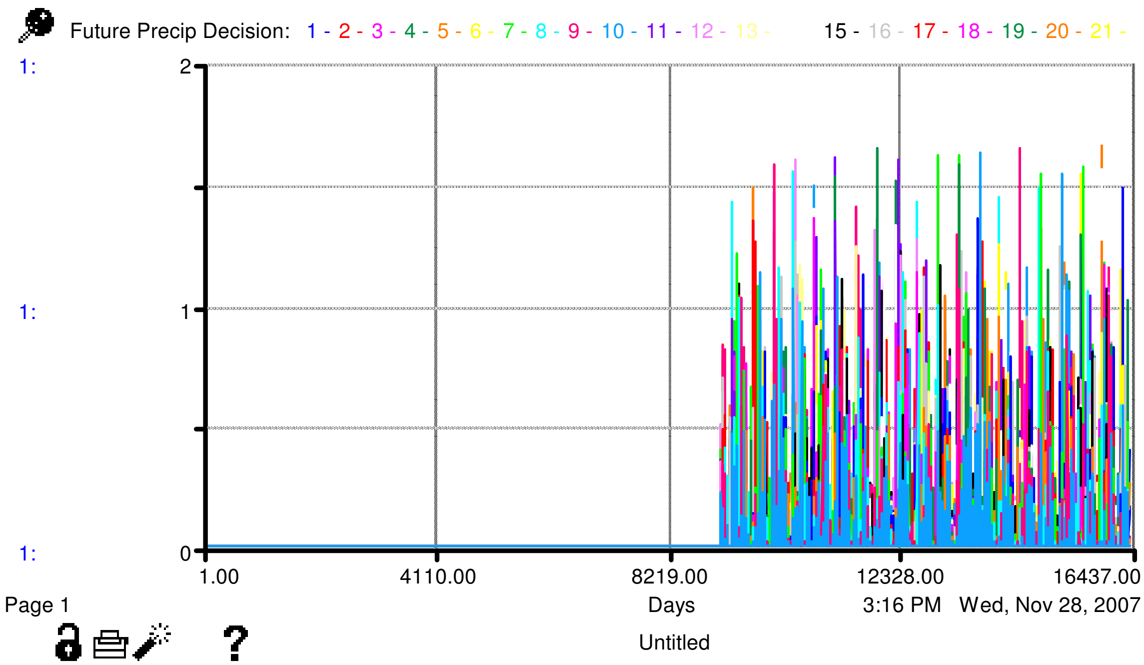


Fig. A.106 - Baseline - precipitation events (inches) observed on a daily timestep – simulated stochastic (100 repetitions).

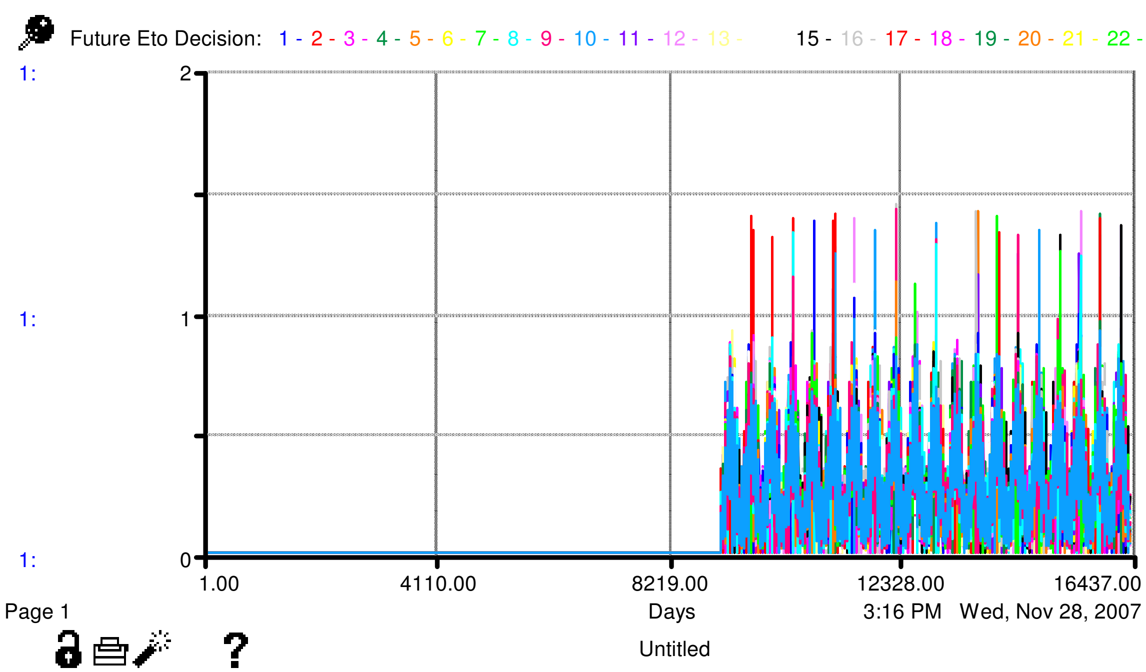


Fig. A.107 - Baseline - evapotranspiration events (inches) observed on a daily timestep – simulated stochastic (100 repetitions).

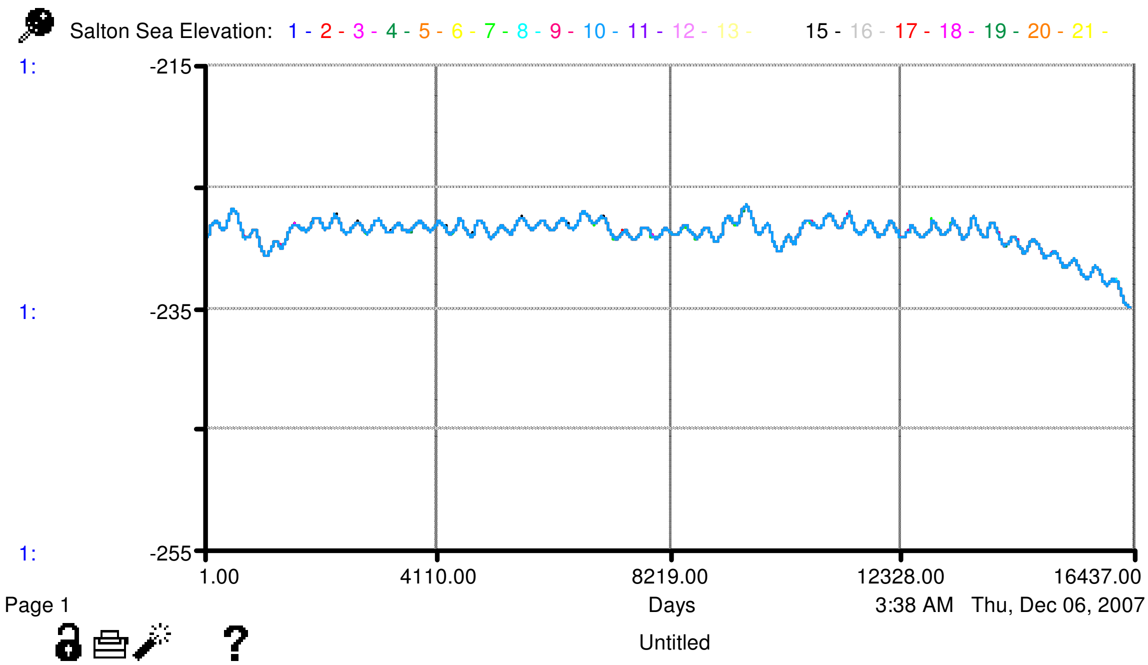


Fig. A.108 - Salton Sea elevation (fasl) after doubling the number of wetlands.

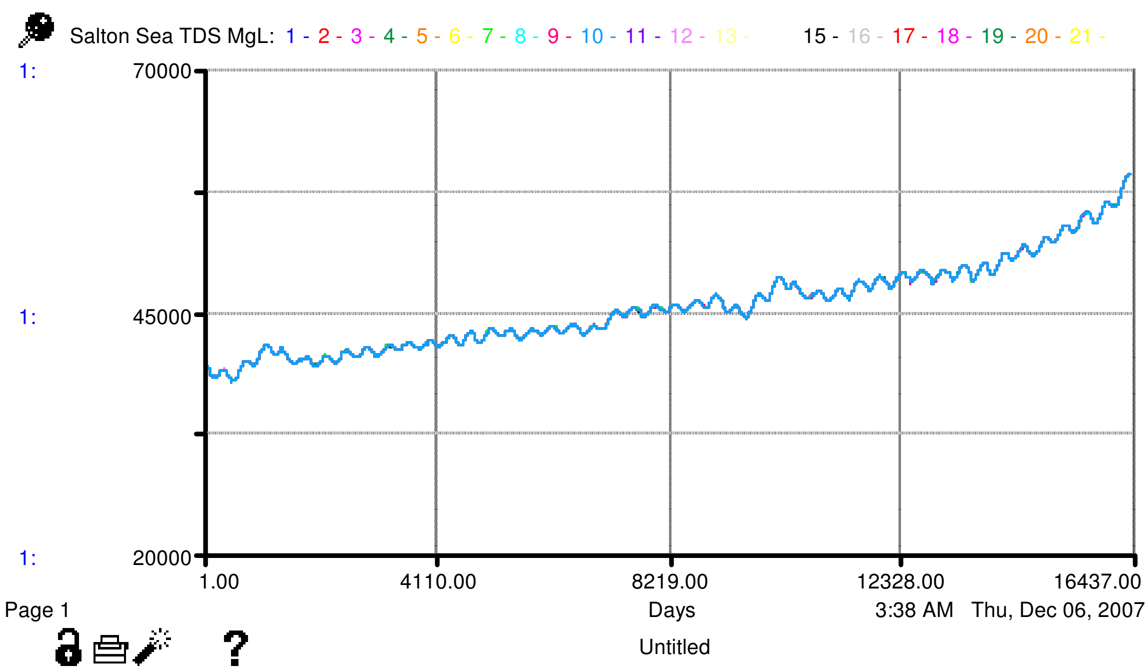


Fig. A.109 - Salton Sea salinity (mg/L) after doubling the number of wetlands.

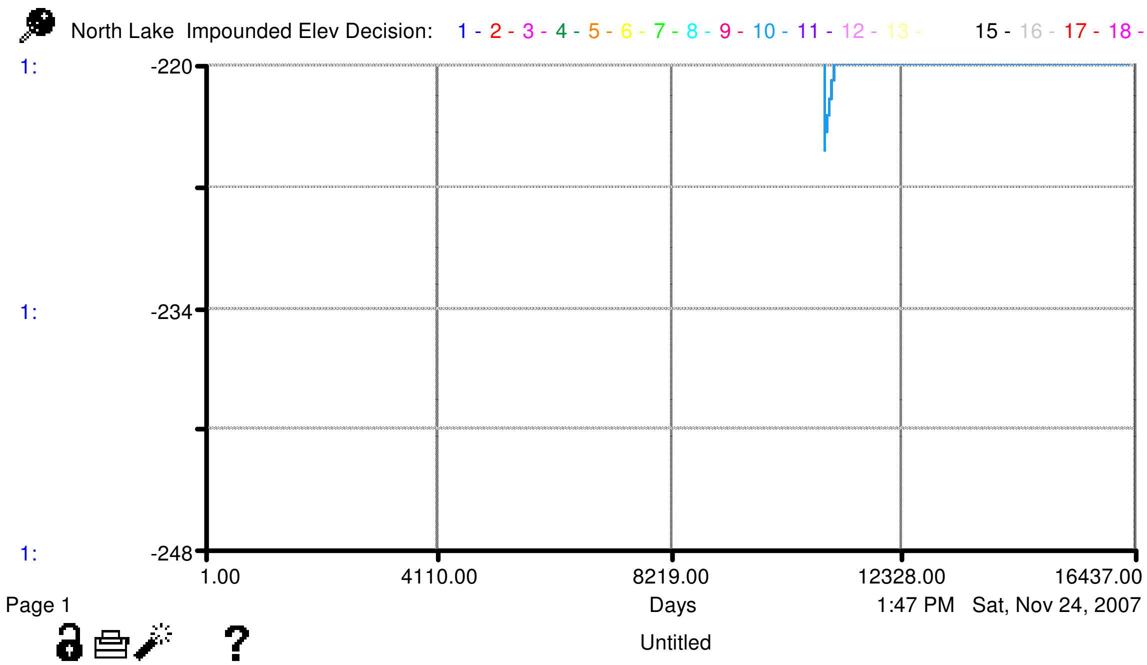


Fig. A.110 - Impoundment design (policy 2) under scenario 2 (deterministic version) - north impoundment elevation (fasl) of Salton Sea.

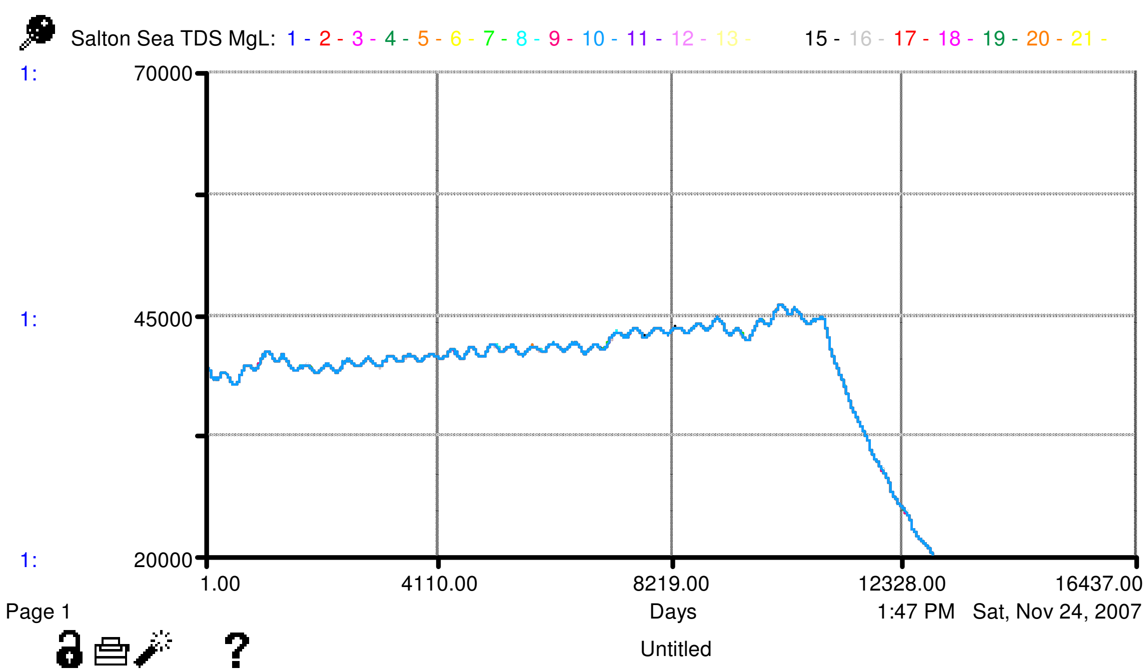


Fig. A.111 - Impoundment design (policy 2) under scenario 2 (deterministic version) - north impoundment salinity (mg/L) of Salton Sea.

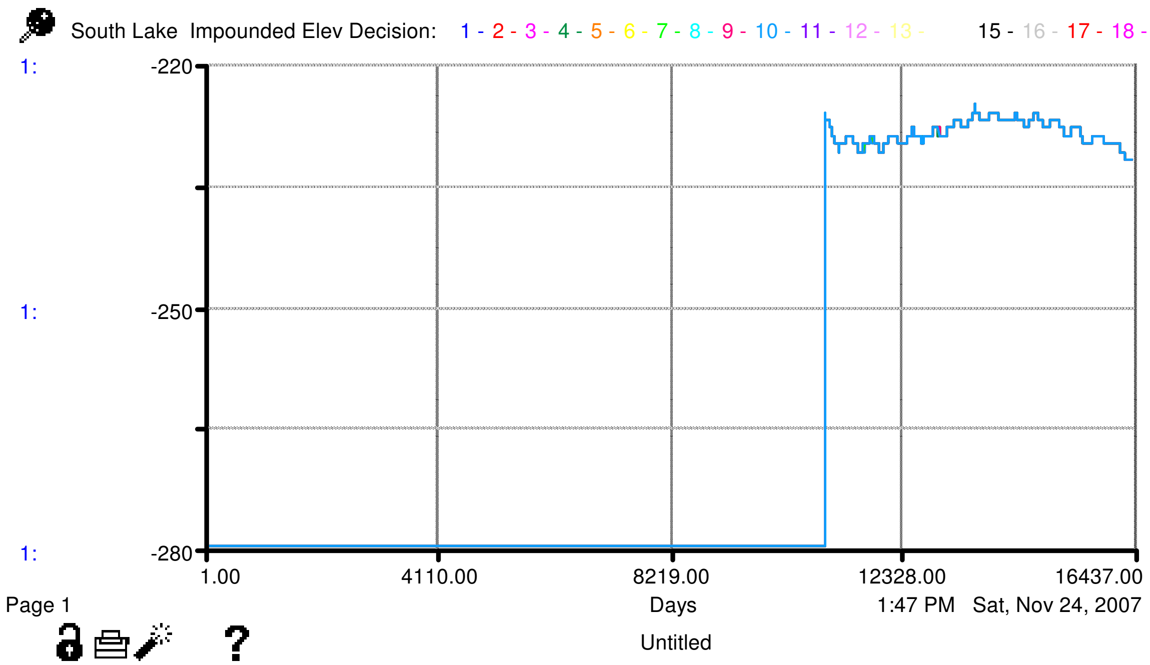


Fig. A.112 - Impoundment design (policy 2) under scenario 2 (deterministic version) - south impoundment elevation (fasl) of Salton Sea.

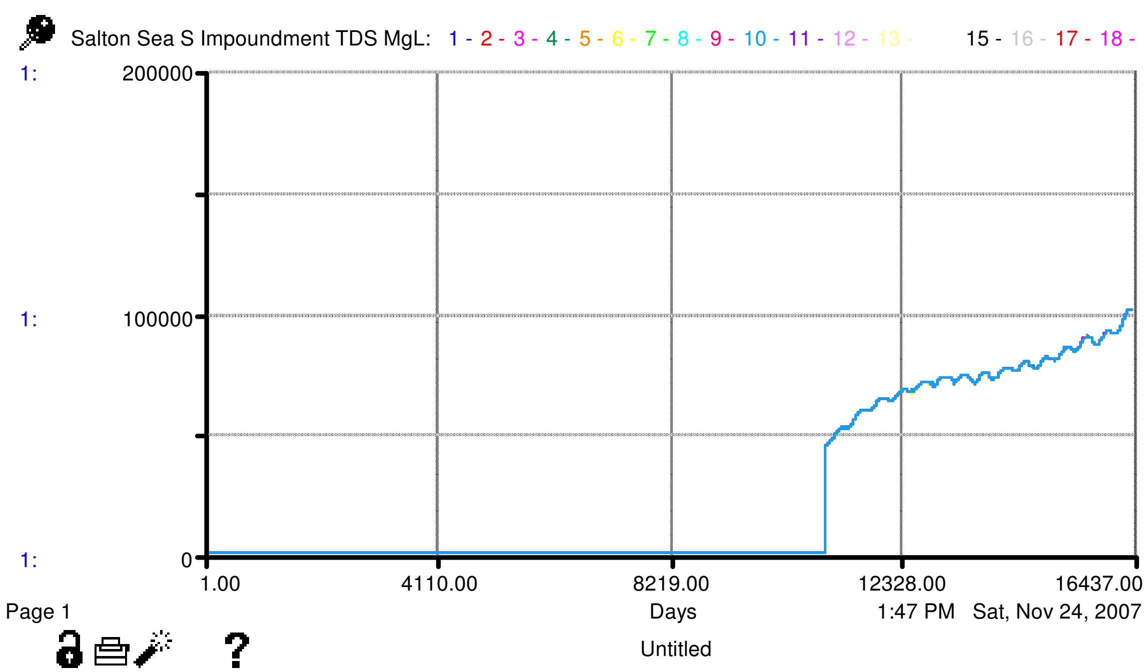


Fig. A.113 - Impoundment design (policy 2) under scenario 2 (deterministic version) - south impoundment salinity (mg/L) of Salton Sea.

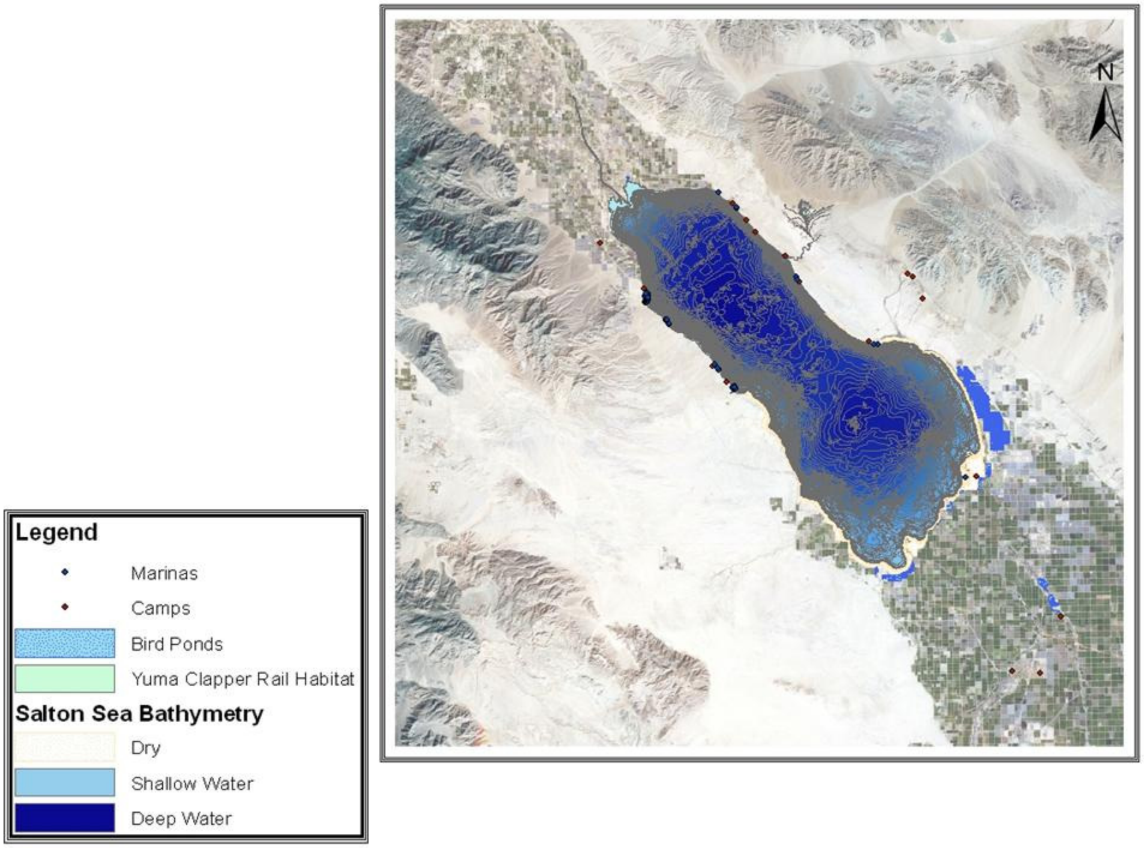


Fig. A.114 - Impoundment design (policy 2) under scenario 2 (deterministic version): Salton Sea south impoundment elevation of -232 fasl at the end of simulation year 2024.

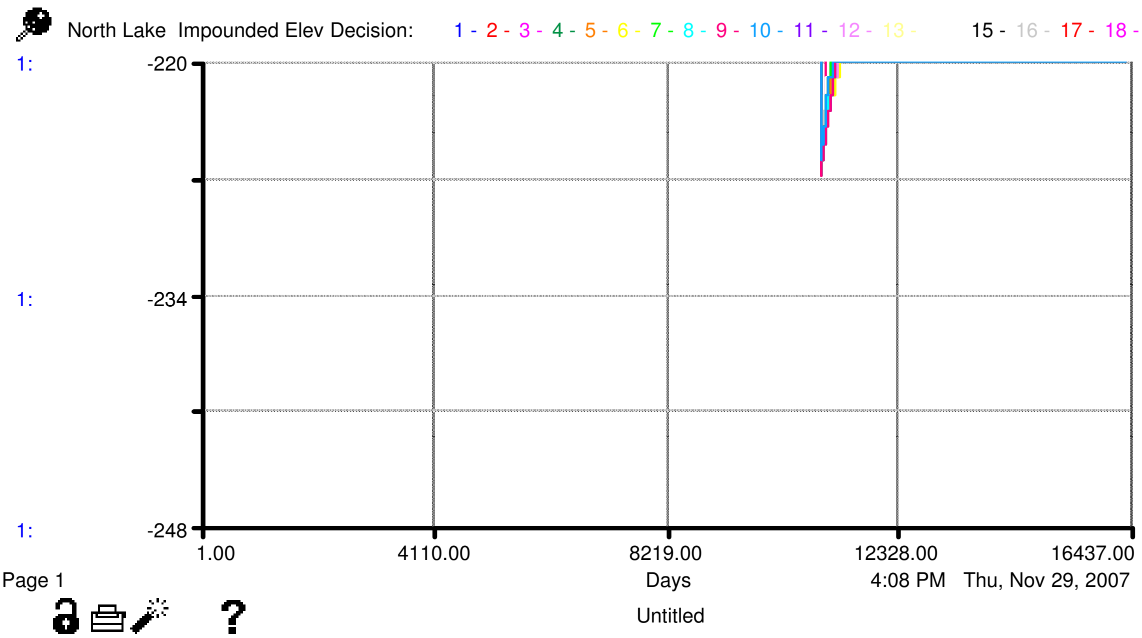


Fig. A.115 - Impoundment design (policy 2) under scenario 2 (stochastic version) - north impoundment elevation (fasl) of Salton Sea.

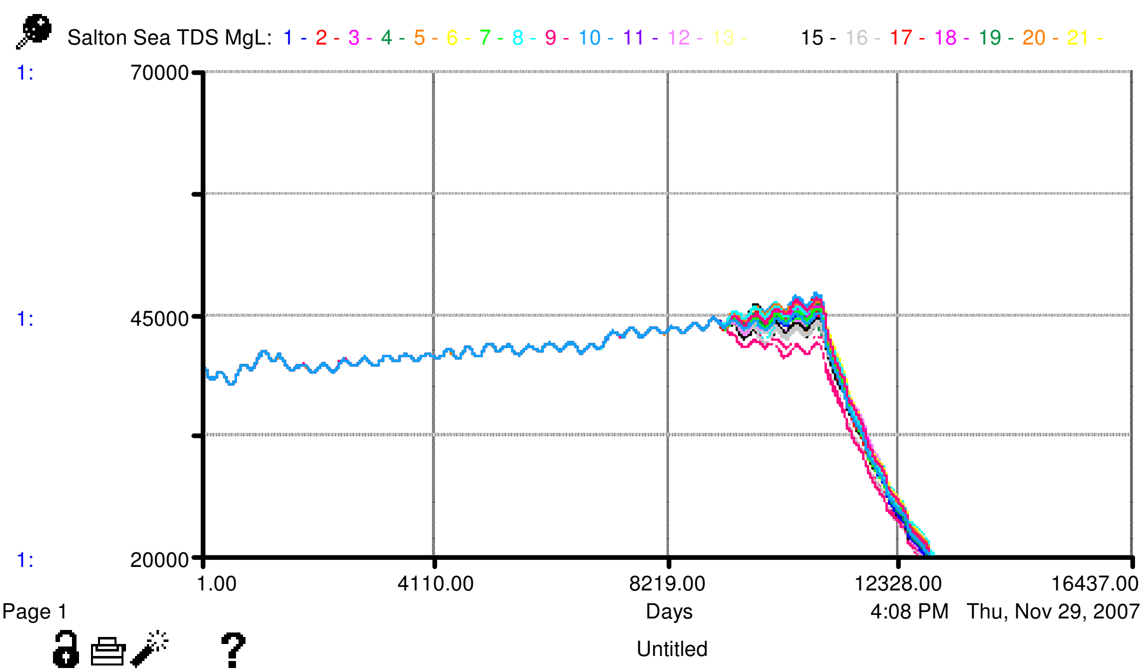


Fig. A.116 - Impoundment design (policy 2) under scenario 2 (stochastic version) - north impoundment salinity (mg/L) of Salton Sea.

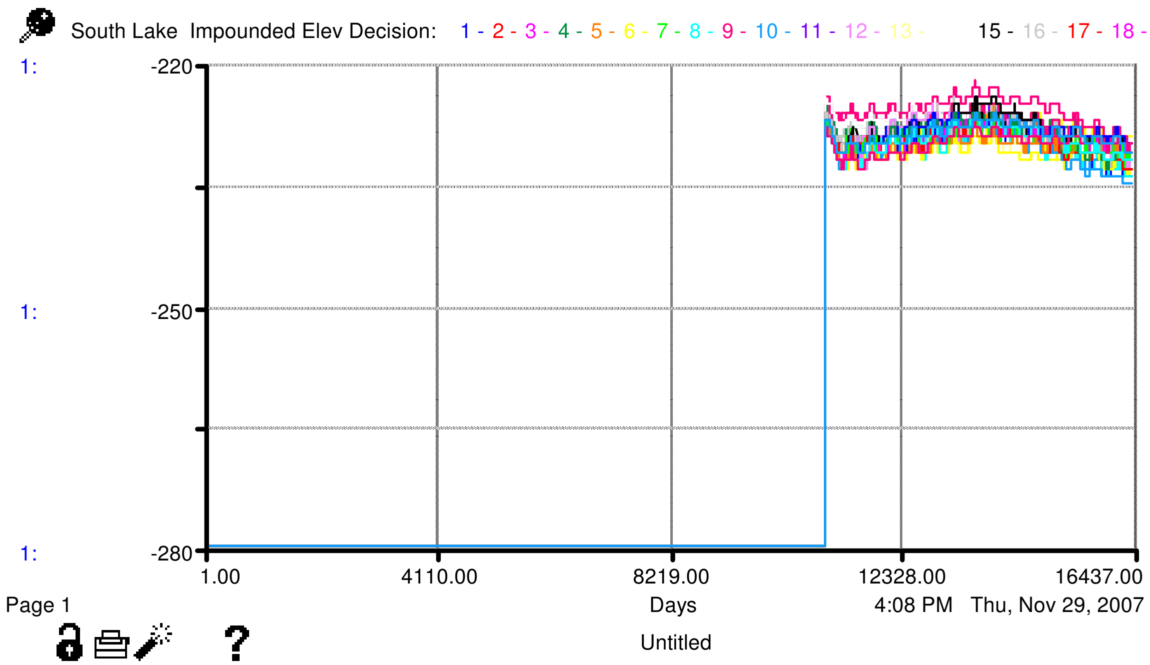


Fig. A.117 - Impoundment design (policy 2) under scenario 2 (stochastic version) - south impoundment elevation (fasl) of Salton Sea.

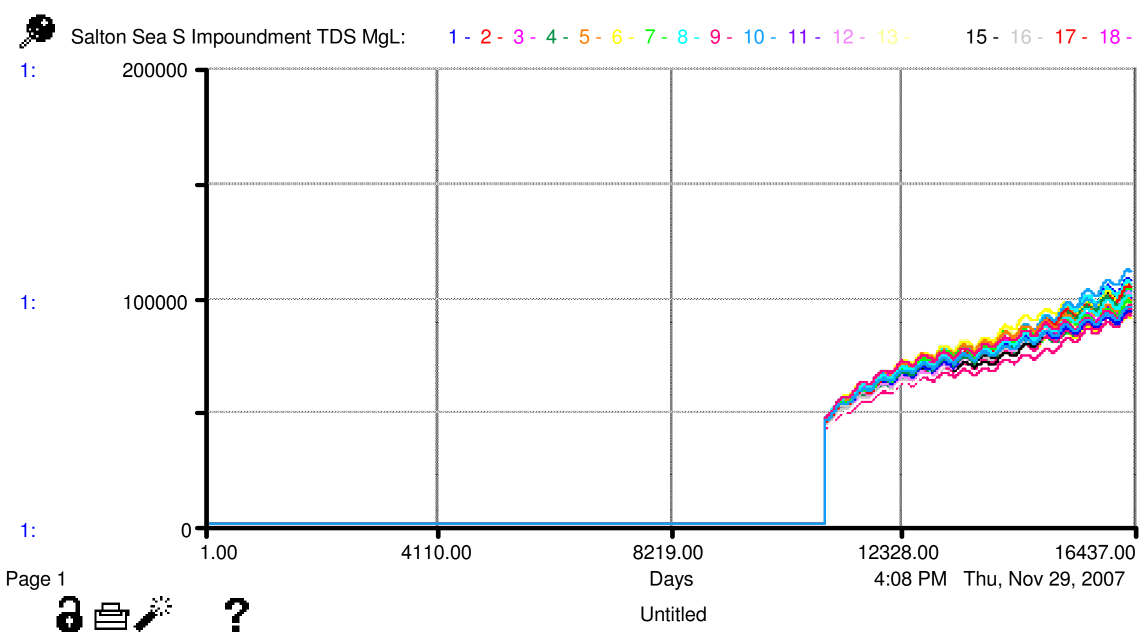


Fig. A.118 - Impoundment design (policy 2) under scenario 2 (stochastic version) - south impoundment salinity (mg/L) of Salton Sea.

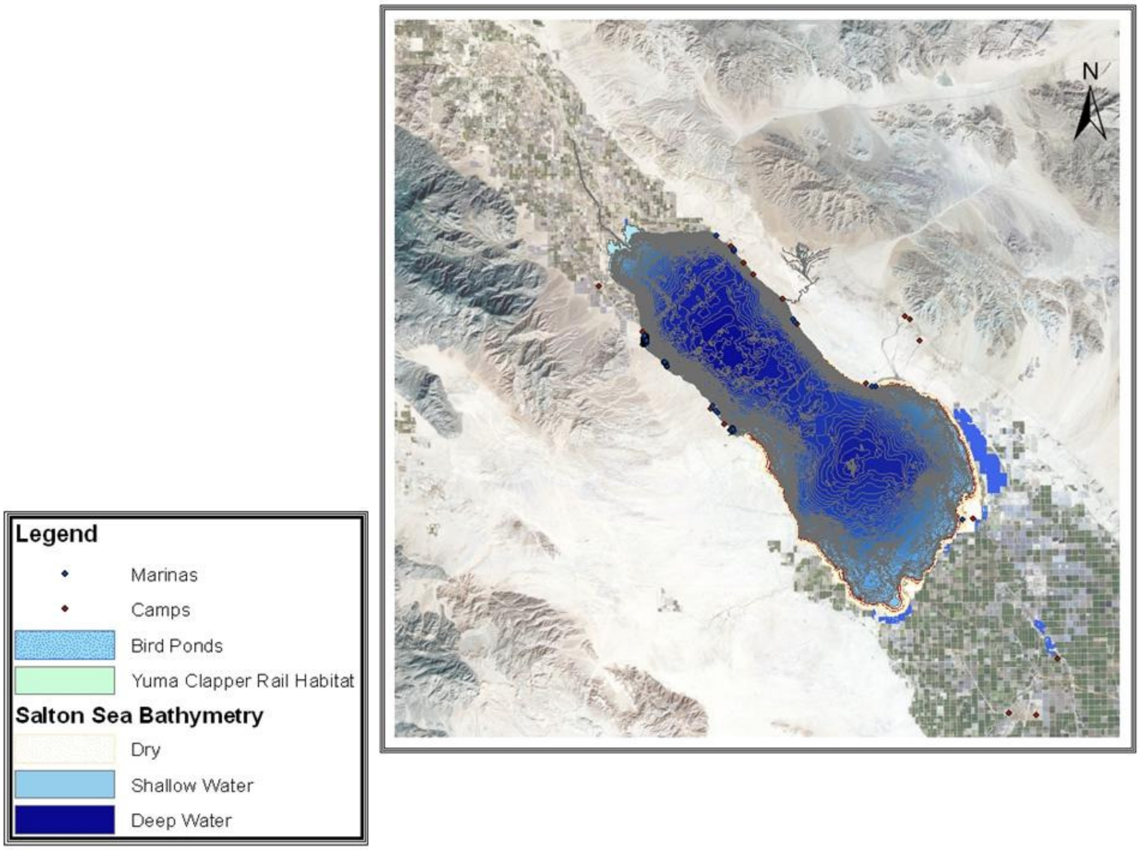


Fig. A.119 - Impoundment design (policy 2) under scenario 2 (stochastic version): Salton Sea south impoundment elevation of -229 fasl at the end of simulation year 2024.

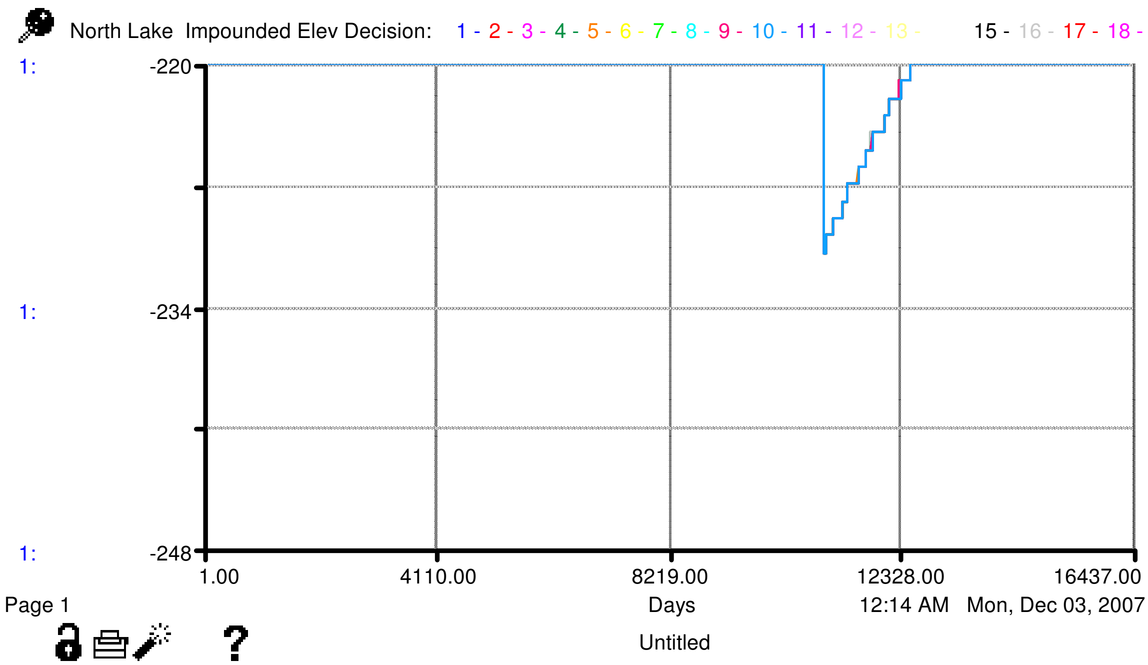


Fig. A.120 - Impoundment design (policy 2) under scenario 3 (deterministic version) - north impoundment elevation (fasl) of Salton Sea.

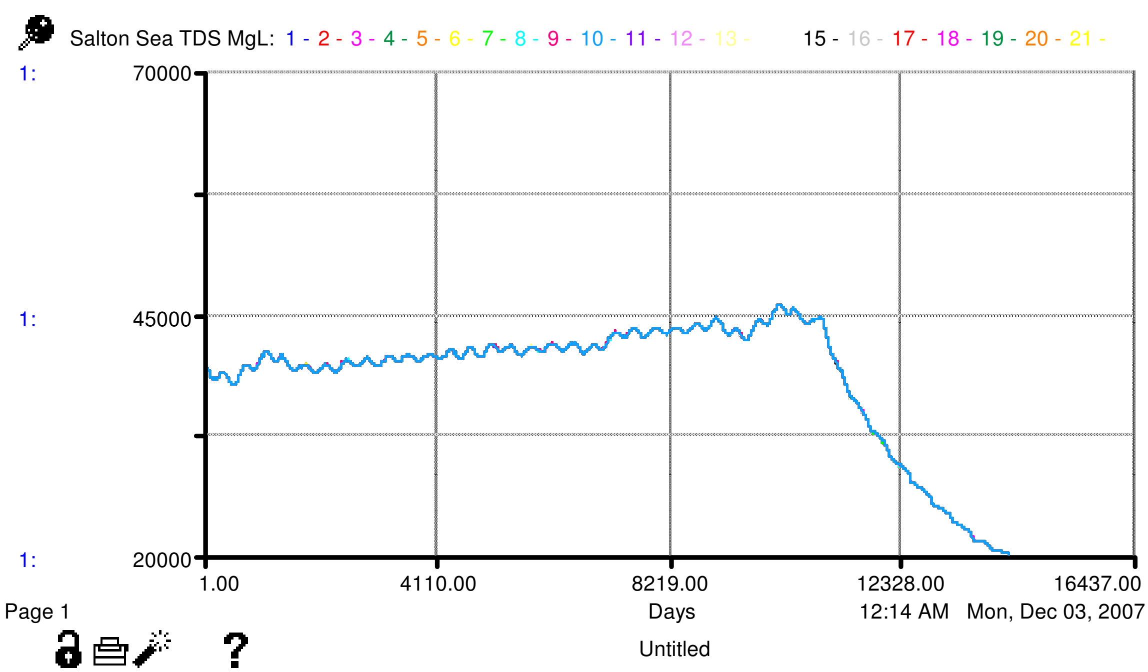


Fig. A.121 - Impoundment design (policy 2) under scenario 3 (deterministic version) - north impoundment salinity (mg/L) of Salton Sea.

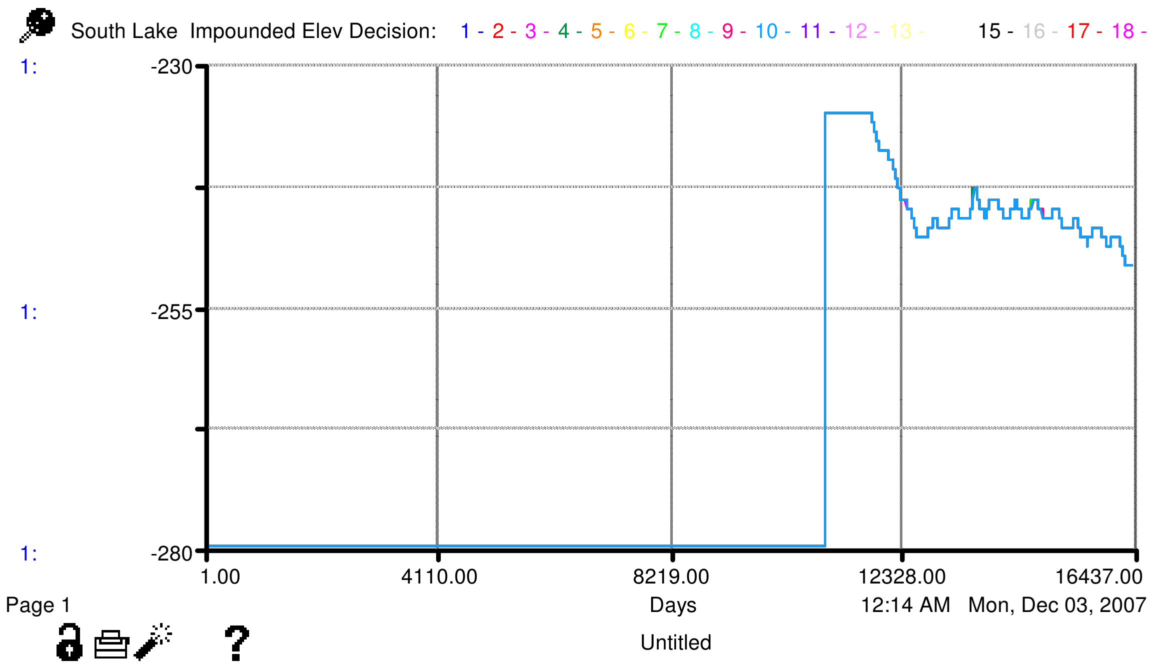


Fig. A.122 - Impoundment design (policy 2) under scenario 3 (deterministic version) - south impoundment elevation (fasl) of Salton Sea.

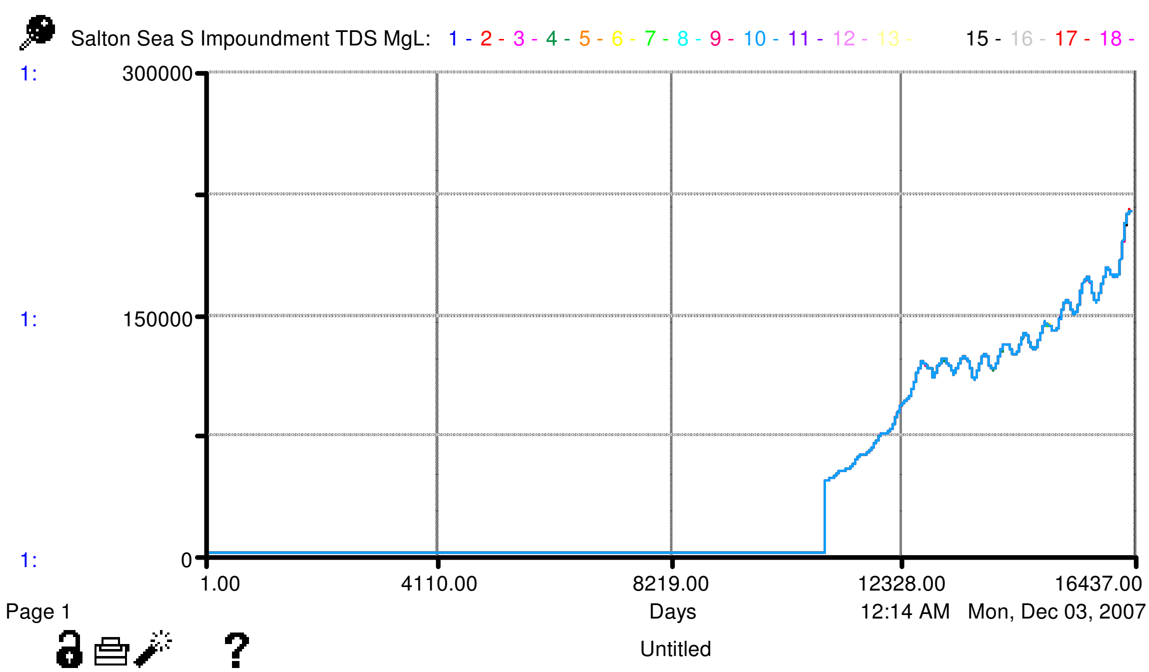


Fig. A.123 - Impoundment design (policy 2) under scenario 3 (deterministic version) - south impoundment salinity (mg/L) of Salton Sea.

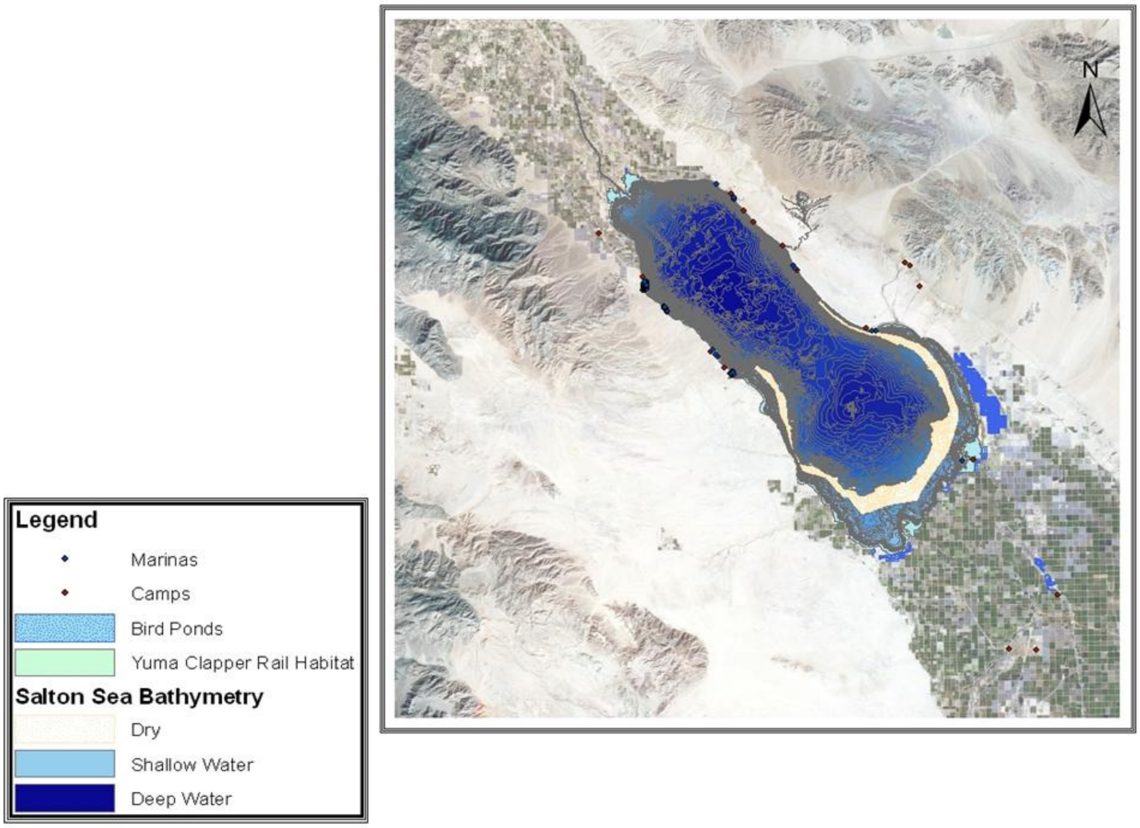


Fig. A.124 - Impoundment design (policy 2) under scenario 3 (deterministic version): Salton Sea south impoundment elevation of -251 fasl at the end of simulation year 2024.

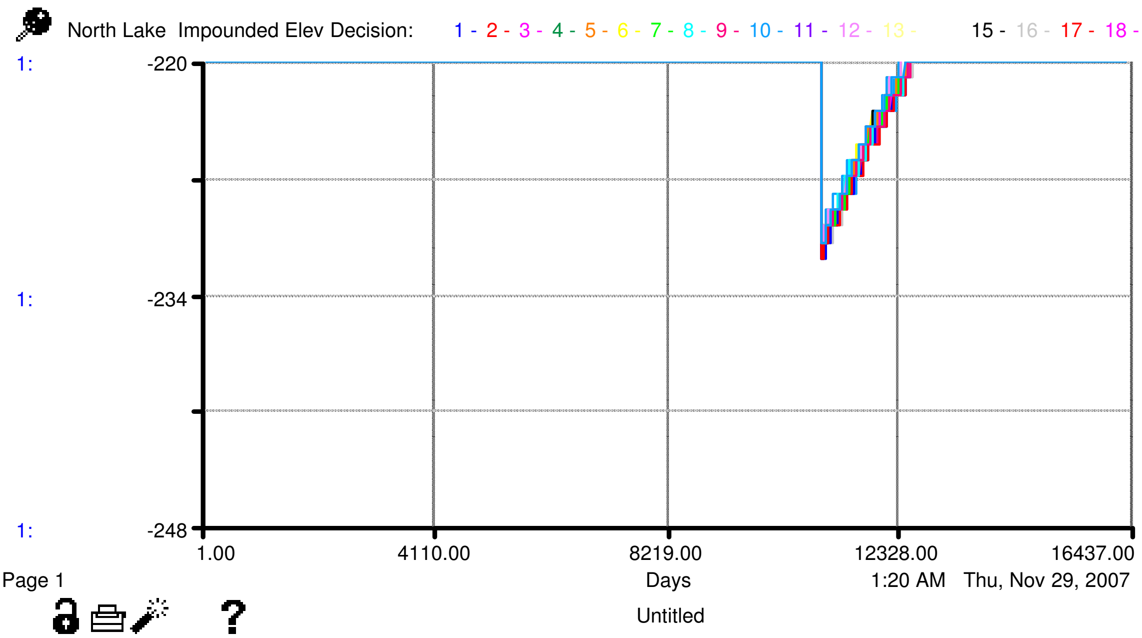


Fig. A.125 - Impoundment design (policy 2) under scenario 3 (stochastic version) - north impoundment elevation (fasl) of Salton Sea.

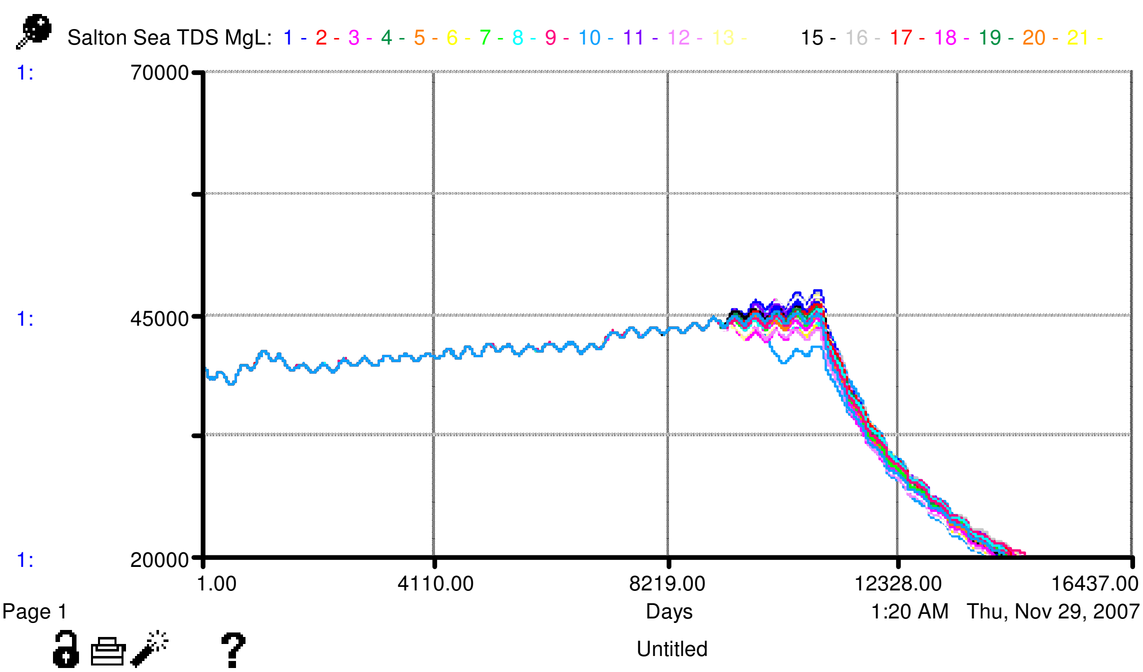


Fig. A.126 - Impoundment design (policy 2) under scenario 3 (stochastic version) - north impoundment salinity (mg/L) of Salton Sea.

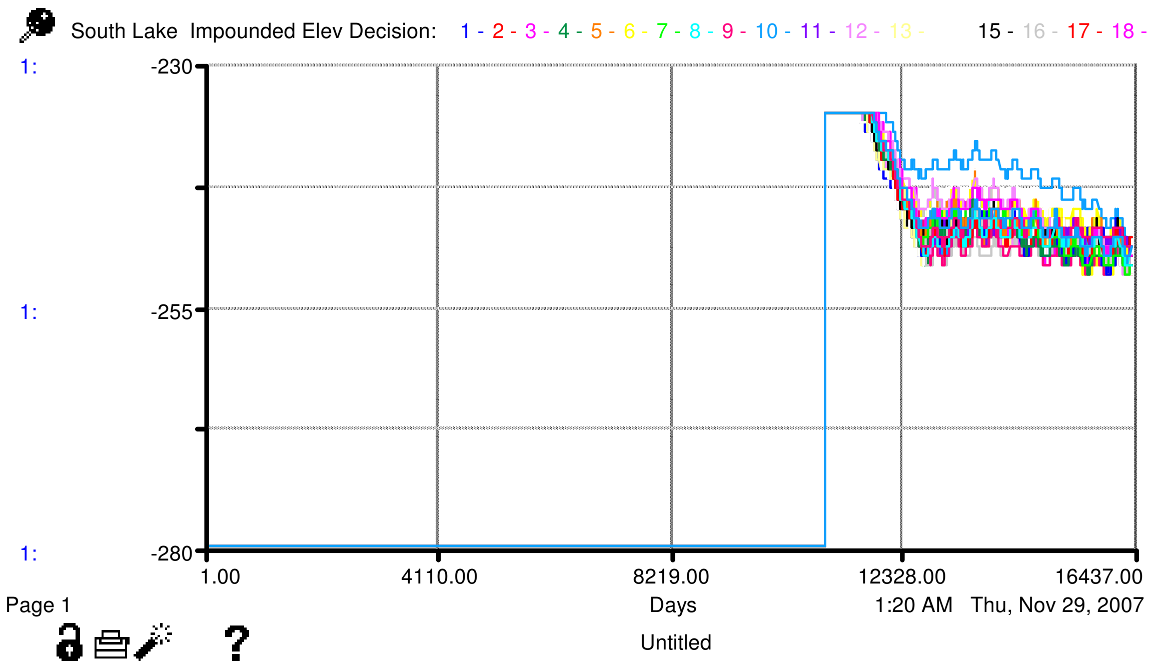


Fig. A.127 - Impoundment design (policy 2) under scenario 3 (stochastic version) - south impoundment elevation (fasl) of Salton Sea.

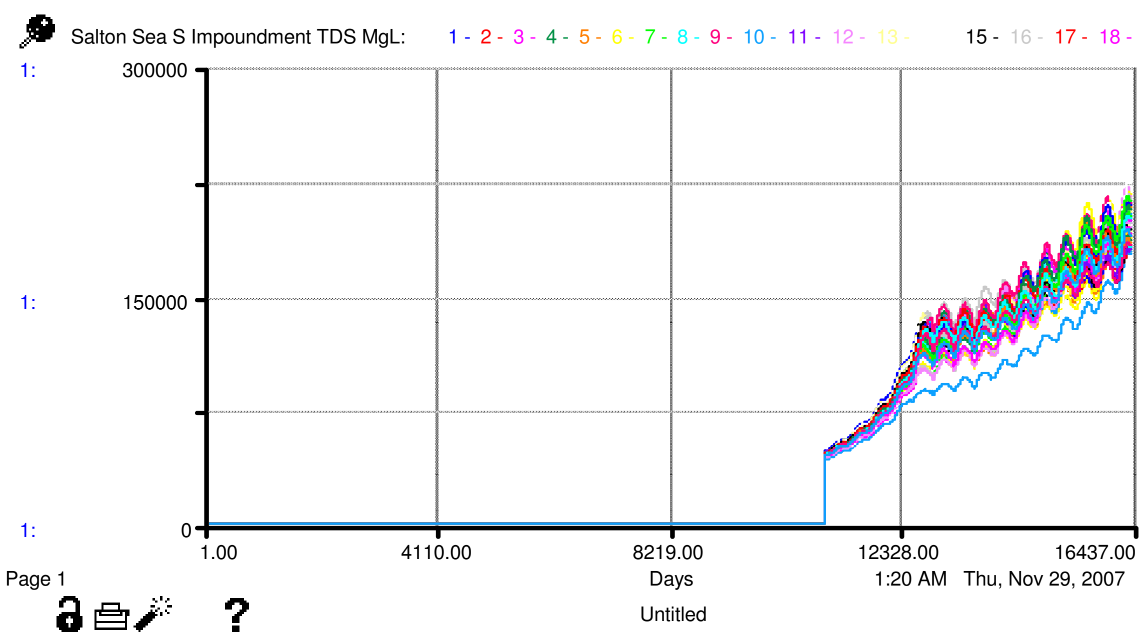


Fig. A.128 - Impoundment design (policy 2) under scenario 3 (stochastic version) - south impoundment salinity (mg/L) of Salton Sea.

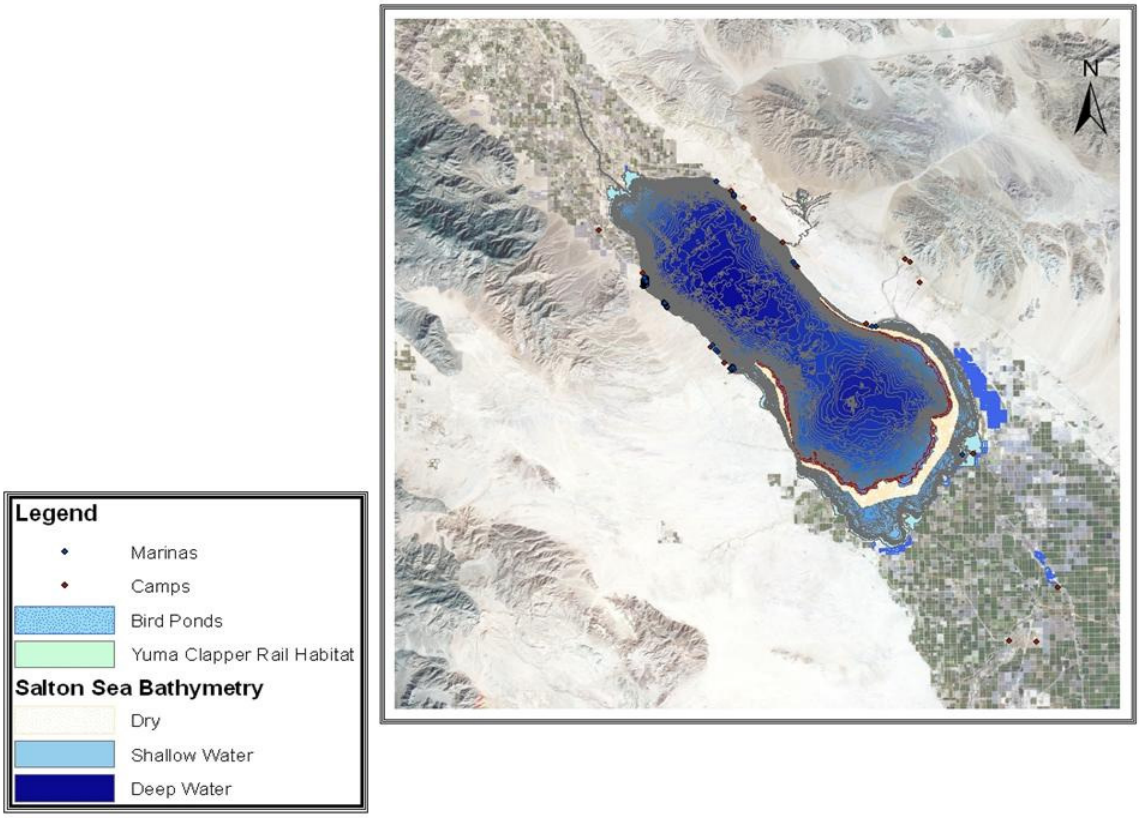


Fig. A.129 - Impoundment design (policy 2) under scenario 3 (stochastic version): Salton Sea south impoundment elevation of -248 fasl at the end of simulation year 2024.

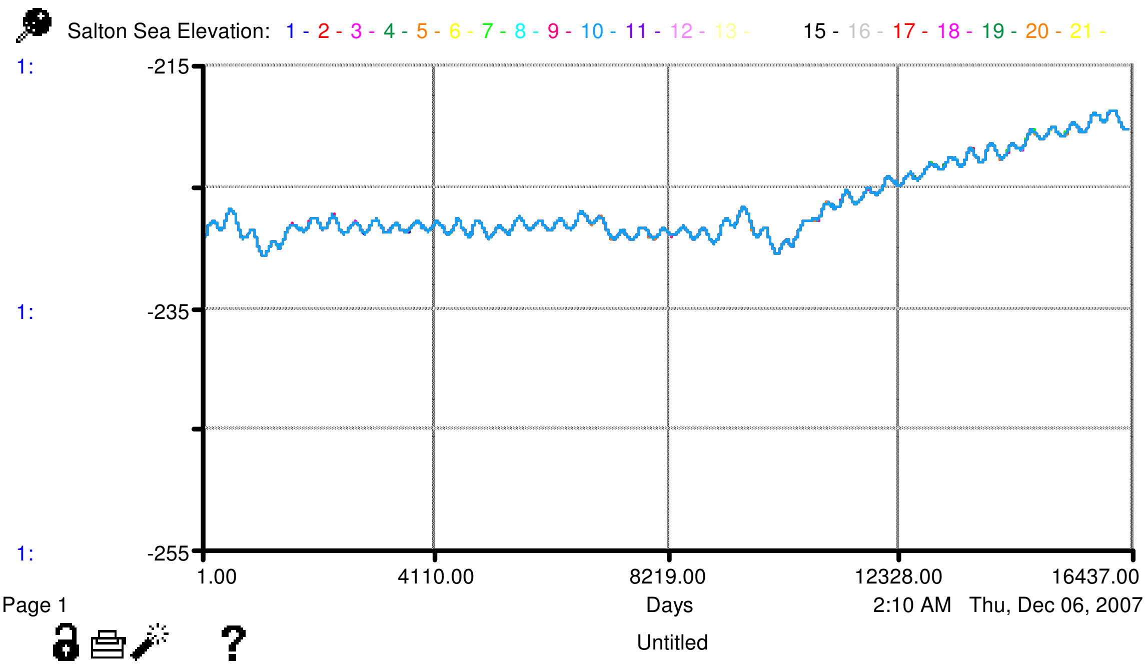


Fig. A.130 - AAC and agricultural fallowing version 2 - Salton Sea elevation (fasl) after lining the AAC with concrete but without implementation of agricultural fallowing.

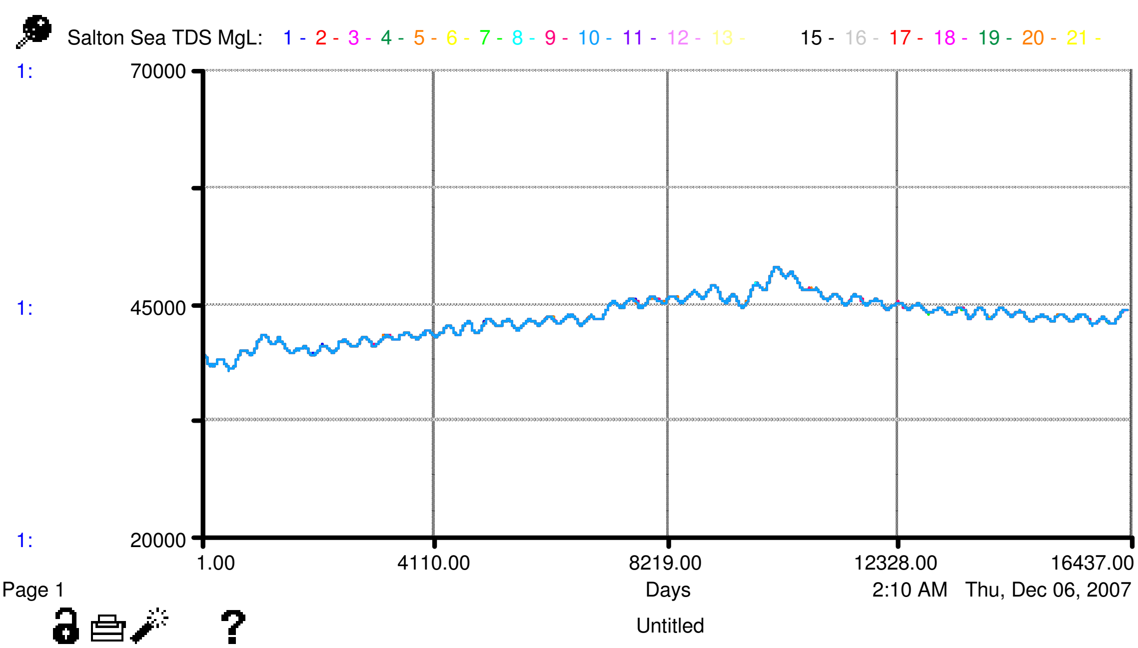


Fig. A.131 - AAC and agricultural fallowing version 2 - Salton Sea salinity (mg/L) after lining the AAC with concrete but without implementation of agricultural fallowing.

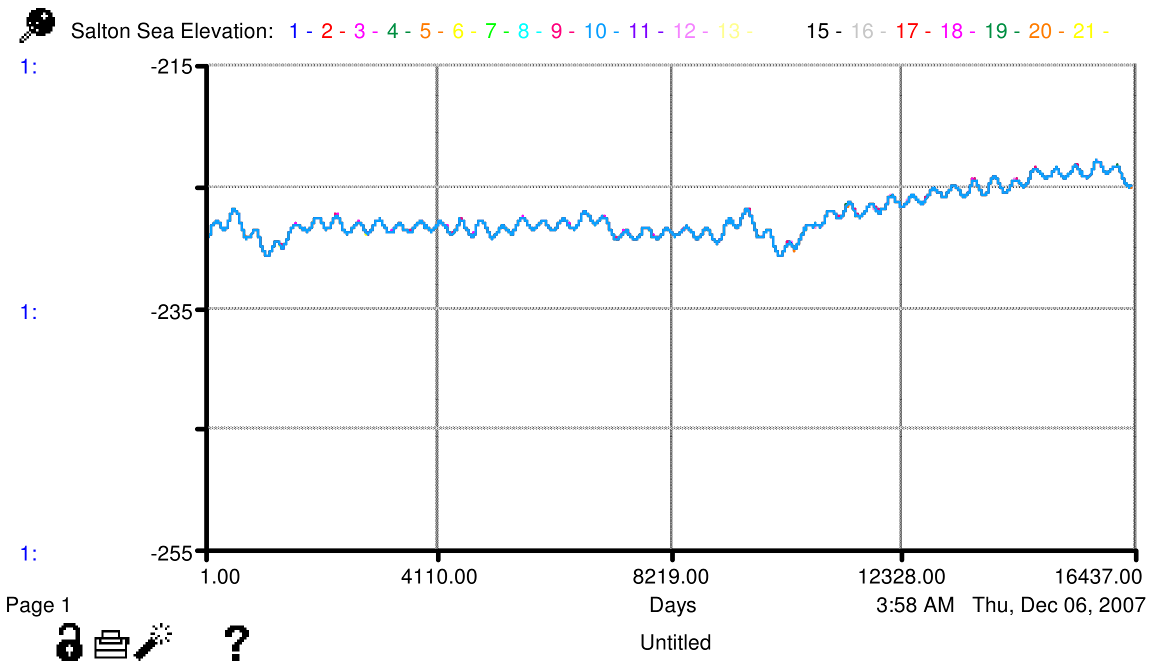


Fig. A.132 - AAC and agricultural fallowing version 3 - Salton Sea elevation (fasl) after lining the AAC with concrete and the implementation of agricultural fallowing but without mitigation water being sent to the sea.

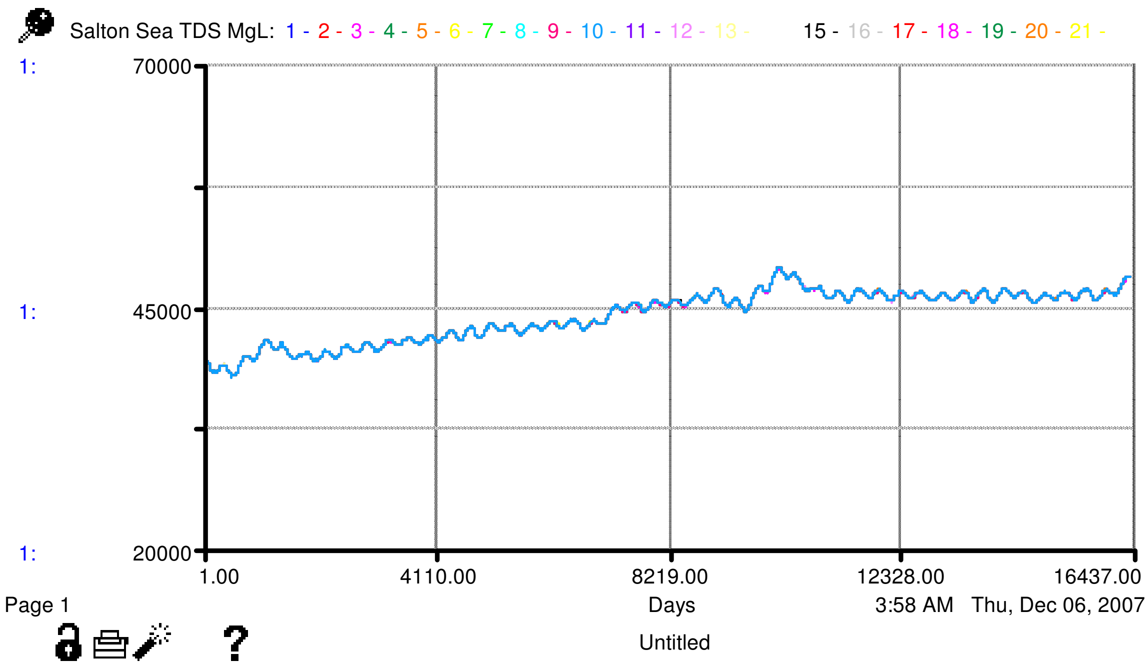


Fig. A.133 - AAC and agricultural fallowing version 3 - Salton Sea salinity (mg/L) after lining the AAC with concrete and the implementation of agricultural fallowing but without mitigation water being sent to the sea.

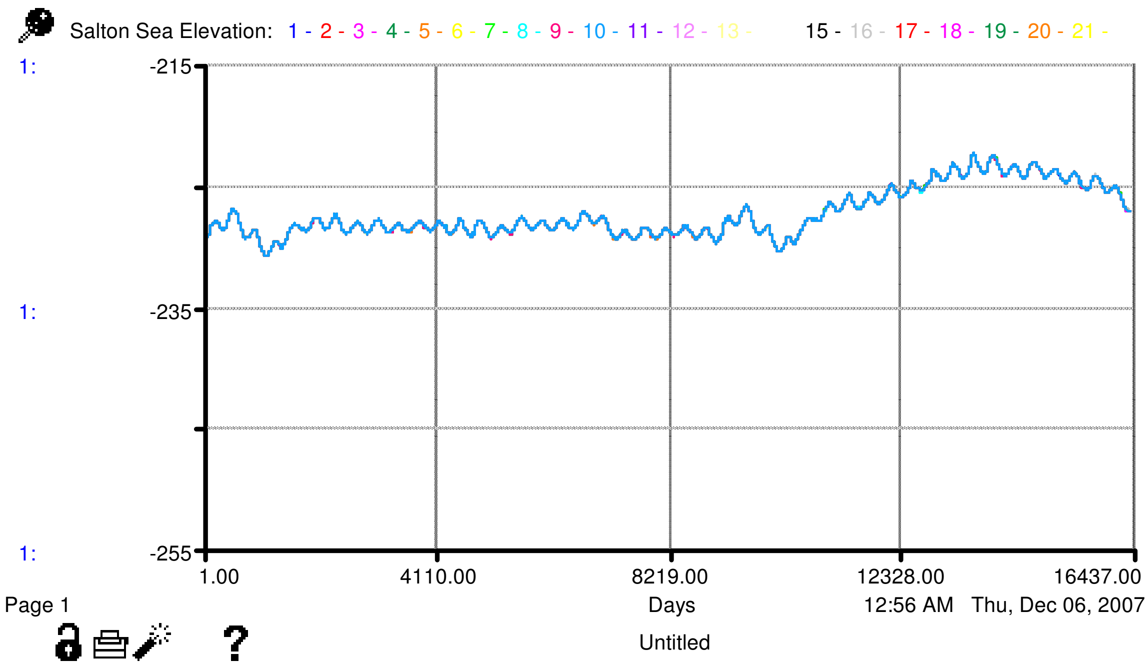


Fig. A.134 - AAC and agricultural fallowing version 4 - Salton Sea elevation (fasl) after lining the AAC with concrete and including the implementation of agricultural fallowing with mitigation water being sent to the sea.

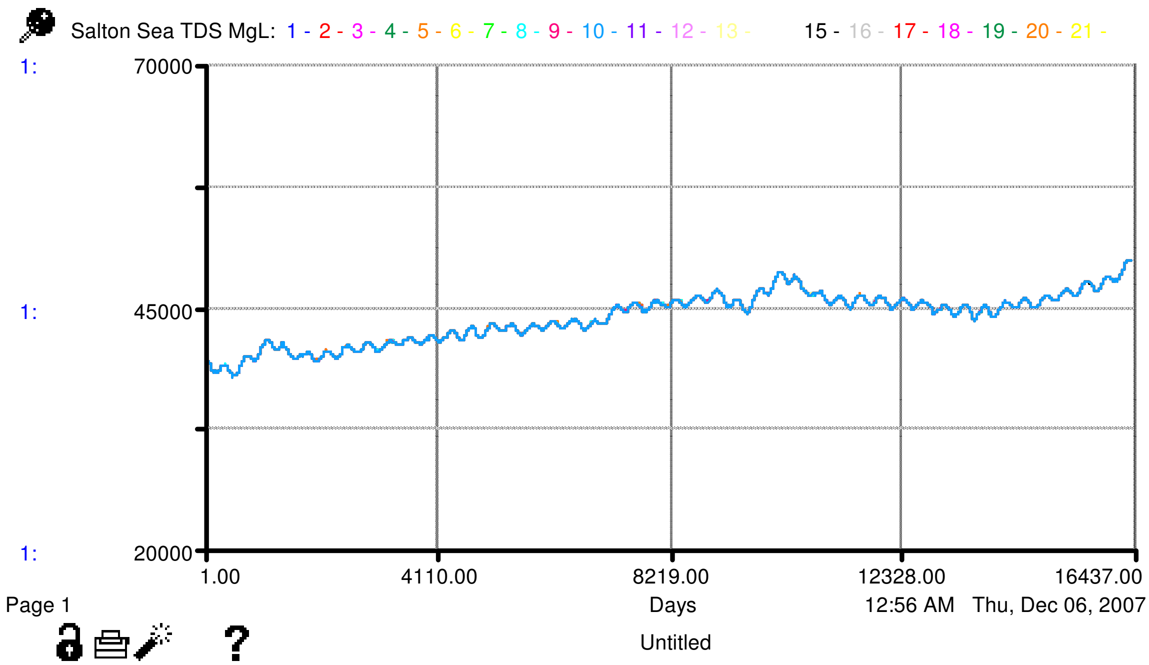


Fig. A.135 - AAC and agricultural fallowing version 4 - Salton Sea salinity (mg/L) after lining the AAC with concrete and including the implementation of agricultural fallowing with mitigation water being sent to the sea.

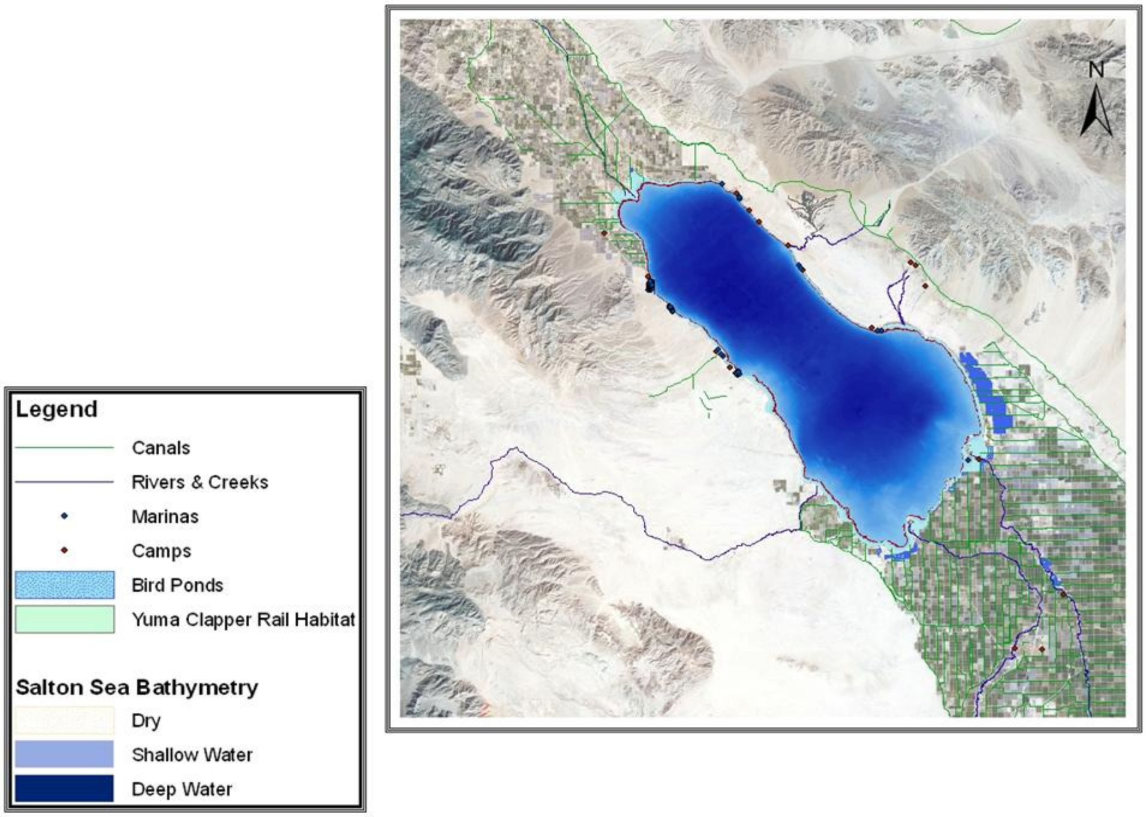


Fig. A.136 - Lining AAC analysis results: Salton Sea lining of AAC results.

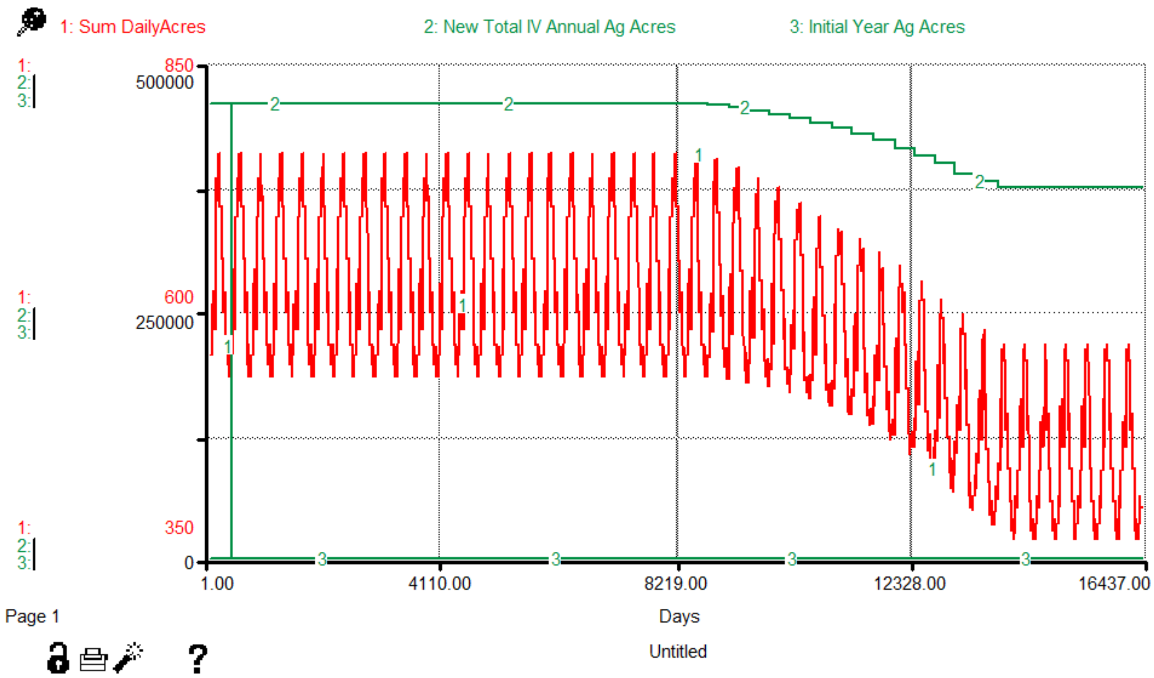


Fig. A.137 - Total crop acres grown and the sum of the number of acres growing observed on a daily timestep.

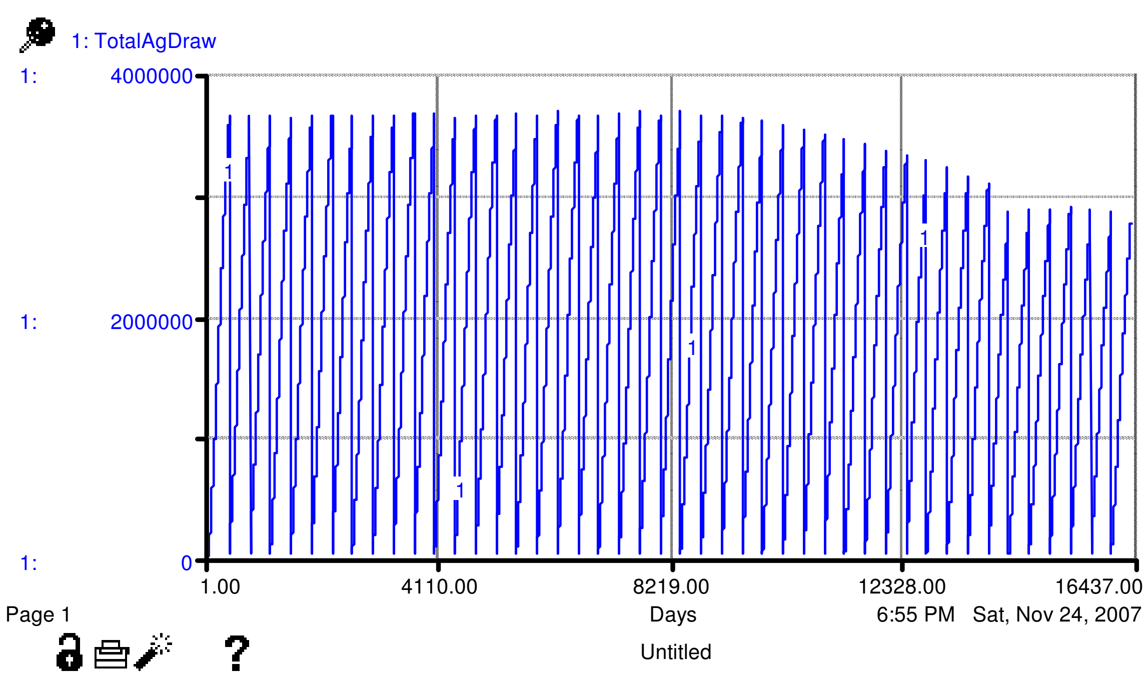


Fig. A.138 - Total agricultural water drawn from the All American Canal based on crop acres growing (acres) over a daily timestep.

Fig. A.139 - Total agricultural employment within the Imperial Valley.

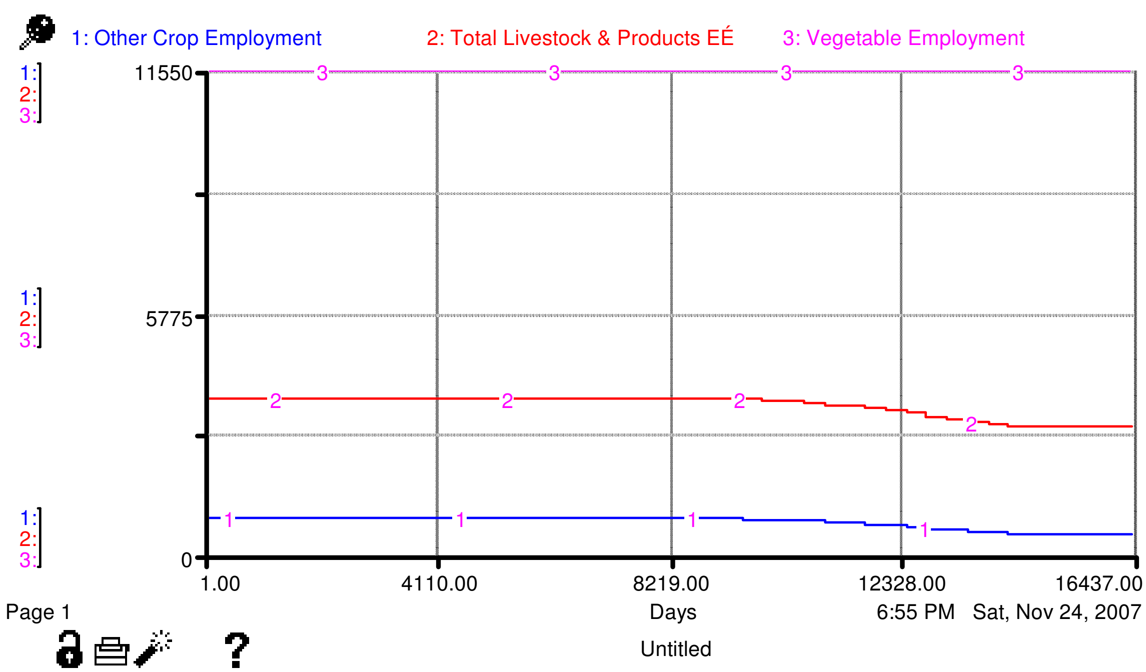


Fig. A.140 - Agricultural employment within the Imperial Valley by category: other crop (1), total livestock and products (2) and vegetable (3).

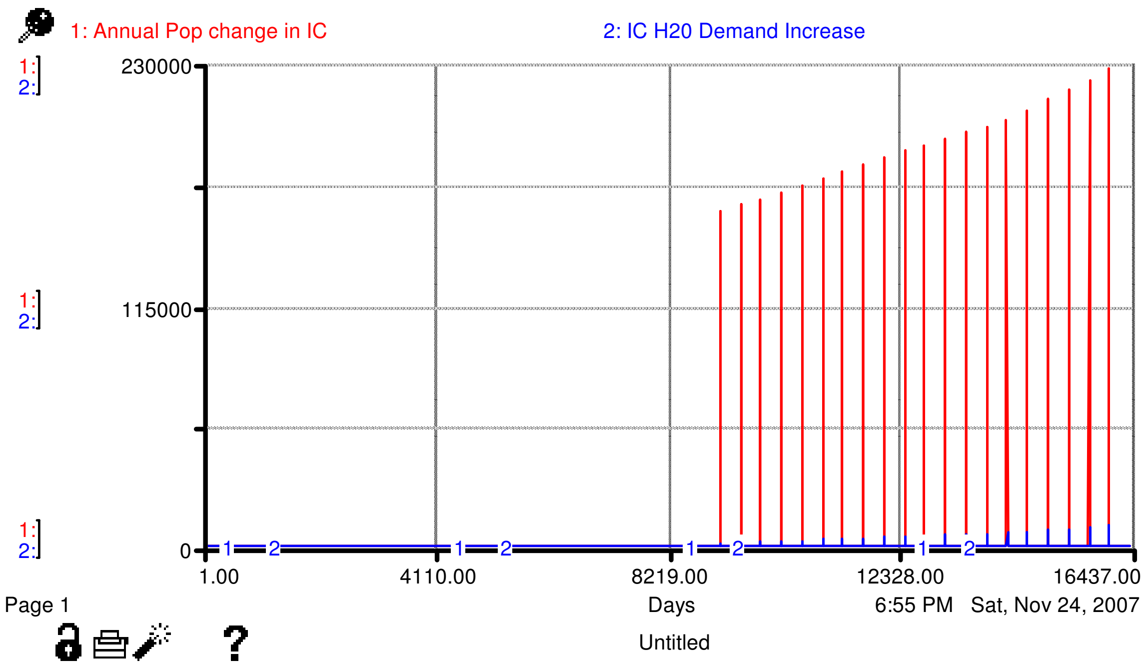


Fig. A.141 - Total population and water demand increase within the Imperial County.

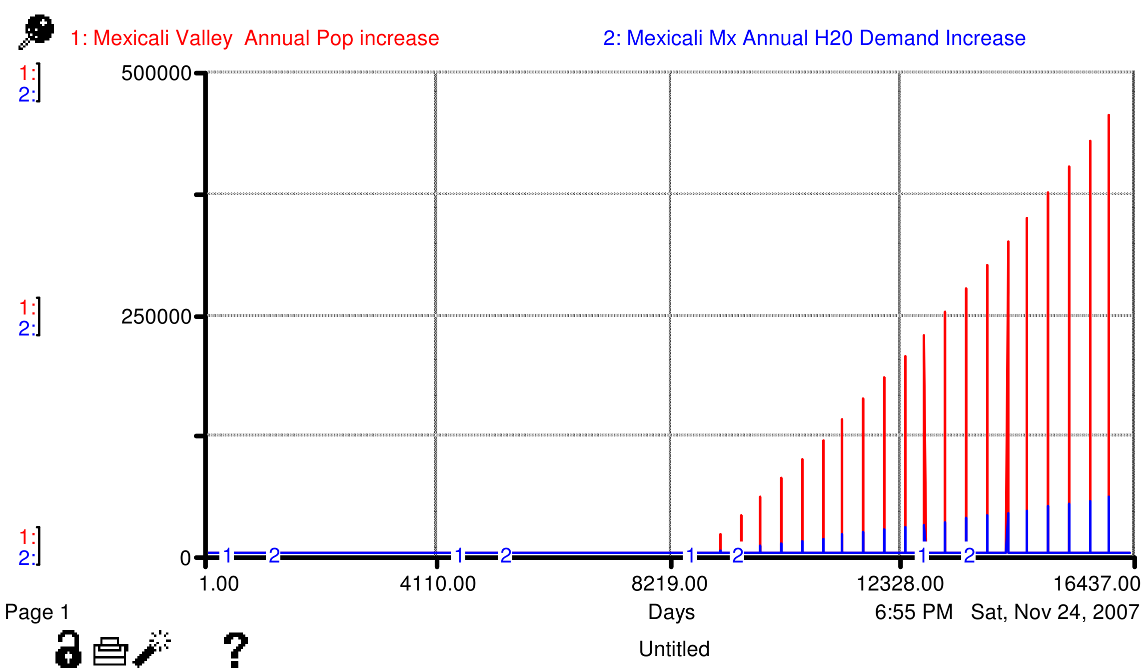


Fig. A.142 - Total population and water demand increase within the Mexicali, Mexico region.

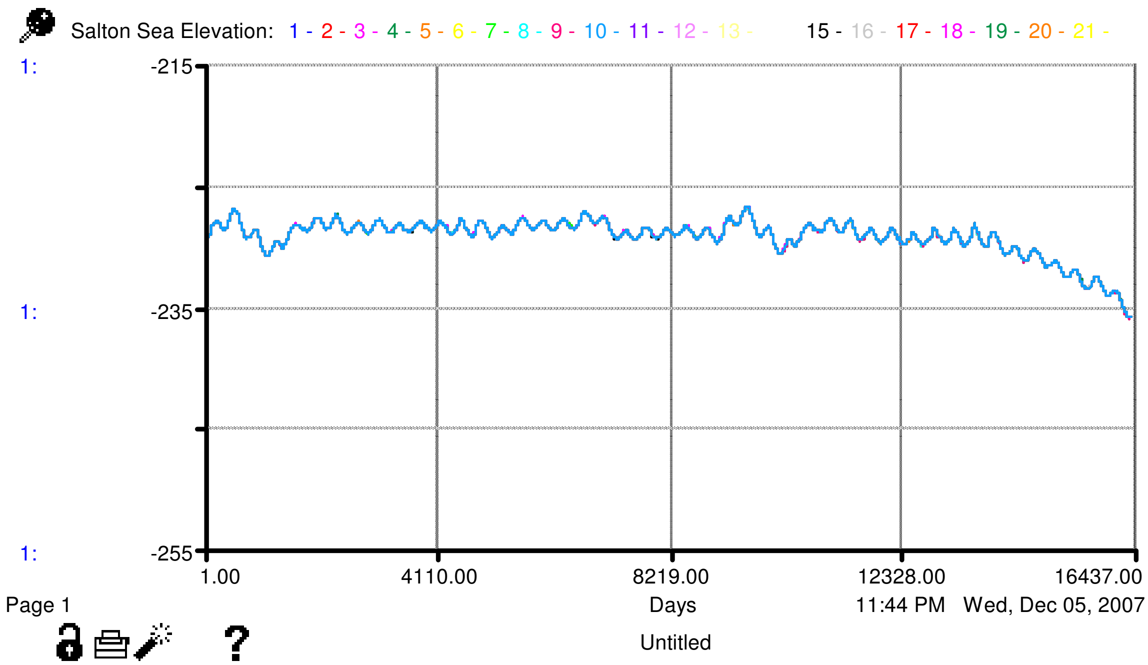


Fig. A.143 - Salton Sea elevation (fasl) after doubling the number of power plants.

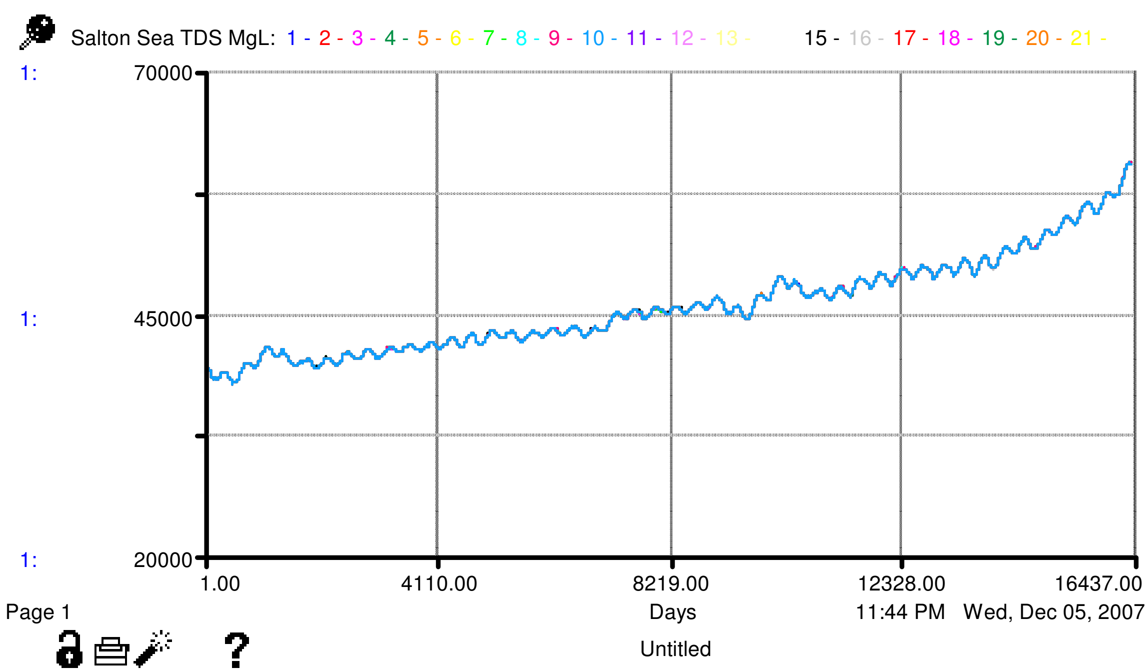


Fig. A.144 - Salton Sea salinity (mg/L) after doubling the number of power plants.

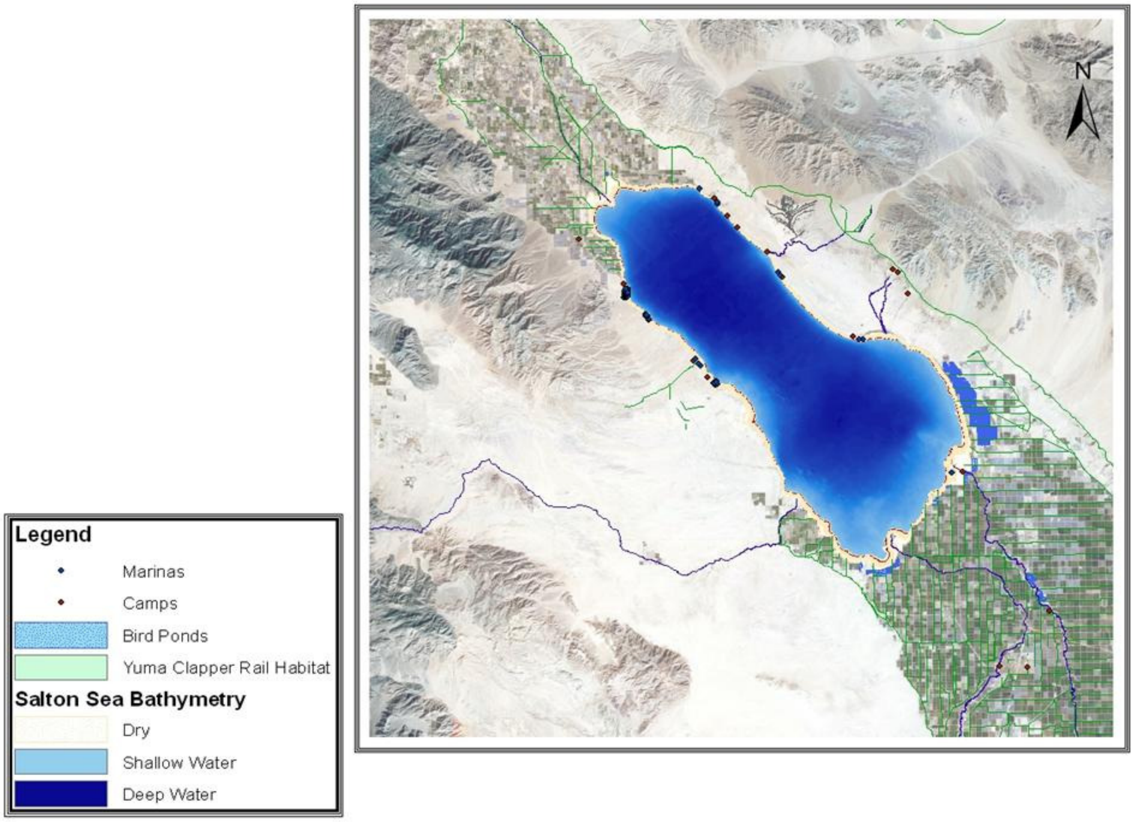


Fig. A.145 - Power plant analysis results: Salton Sea and the operation of power plants results.

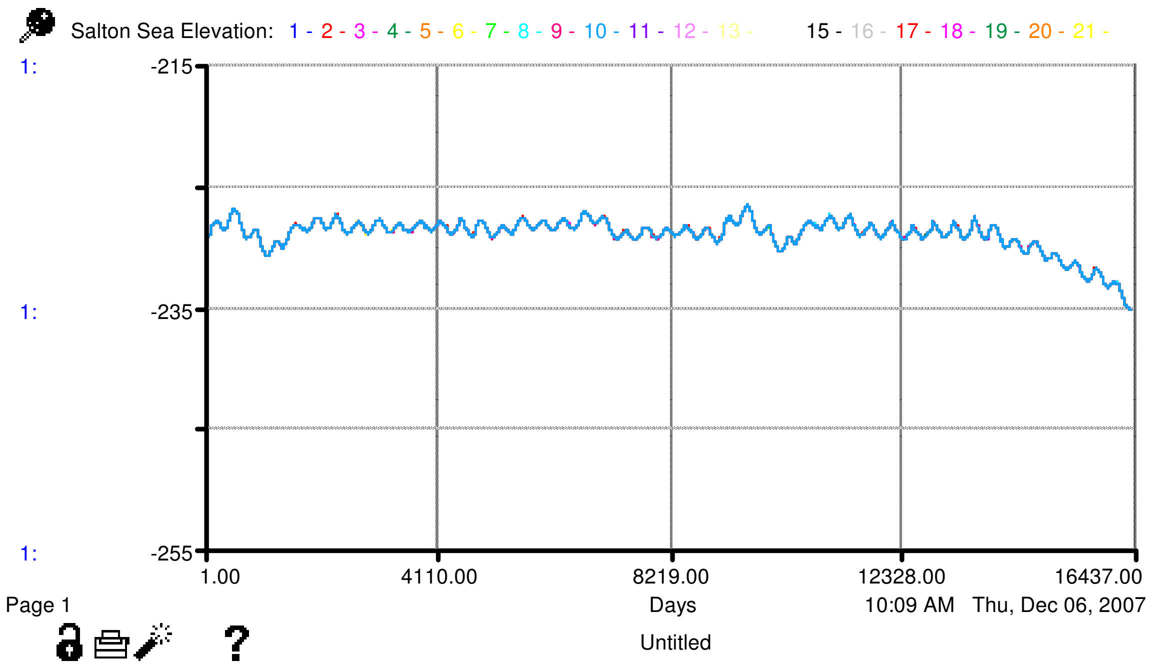


Fig. A.146 - Salton Sea elevation (fasl) after doubling the brine extraction rate.

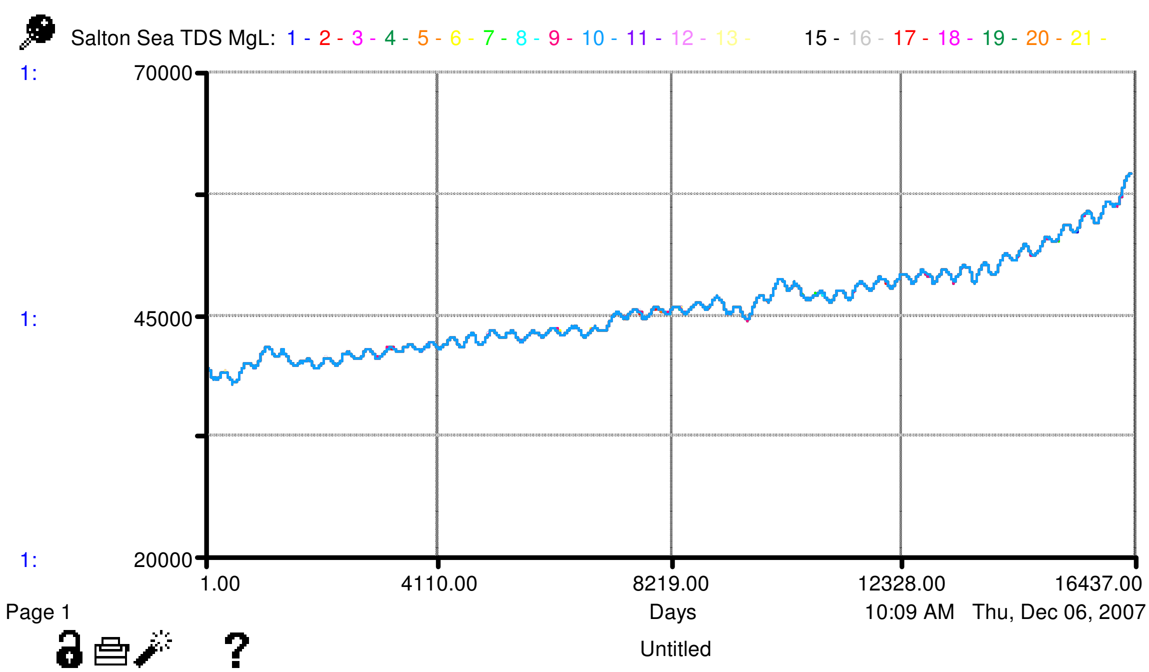


Fig. A.147 - Salton Sea salinity (mg/L) after doubling the brine extraction rate.

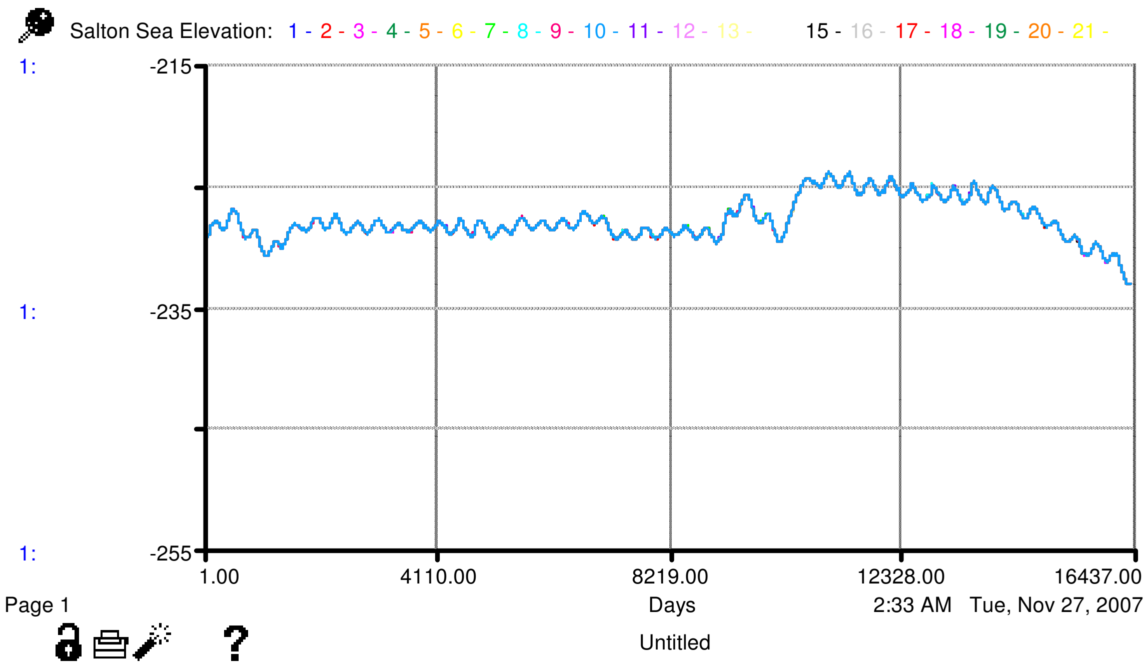


Fig. A.148 - Climate version 2 and precipitation and river flow version 1 (deterministic) - Salton Sea elevation (fasl) after a ten percent increase in precipitation and river flows while holding evaporation and transpiration constant.

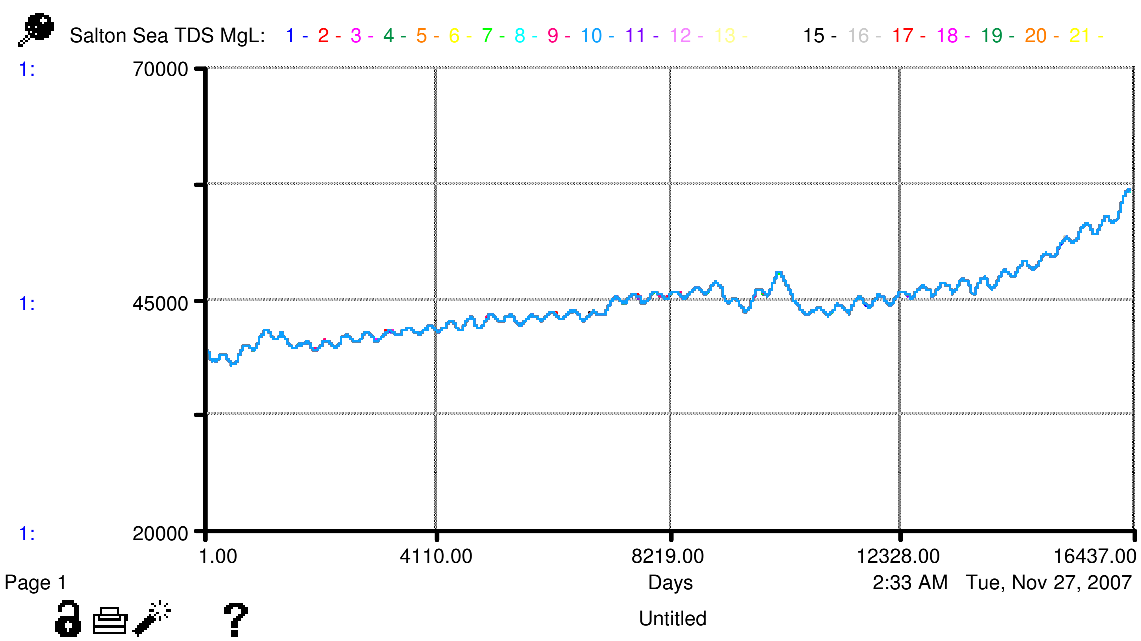


Fig. A.149 - Climate version 2 and precipitation and river flow version 1 (deterministic) - Salton Sea salinity (mg/L) after a ten percent increase in precipitation and river flows while holding evaporation and transpiration constant.

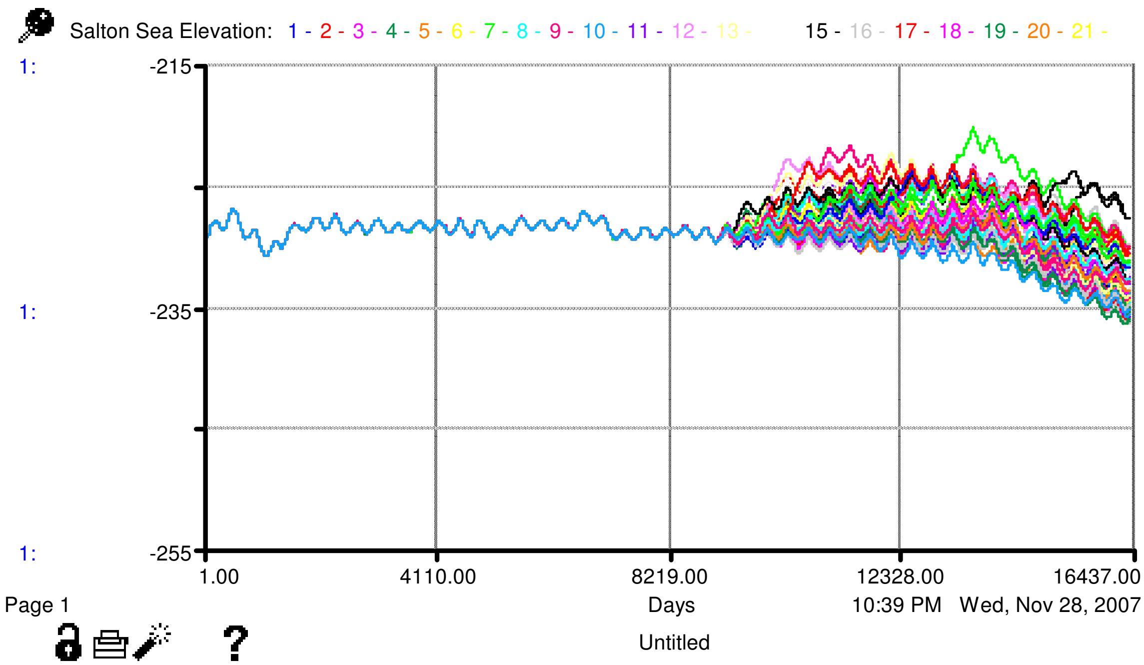


Fig. A.150 - Climate version 2 and precipitation and river flow version 2 (stochastic) - Salton Sea elevation (fasl) after a ten percent increase in precipitation and river flows while holding evaporation and transpiration constant.

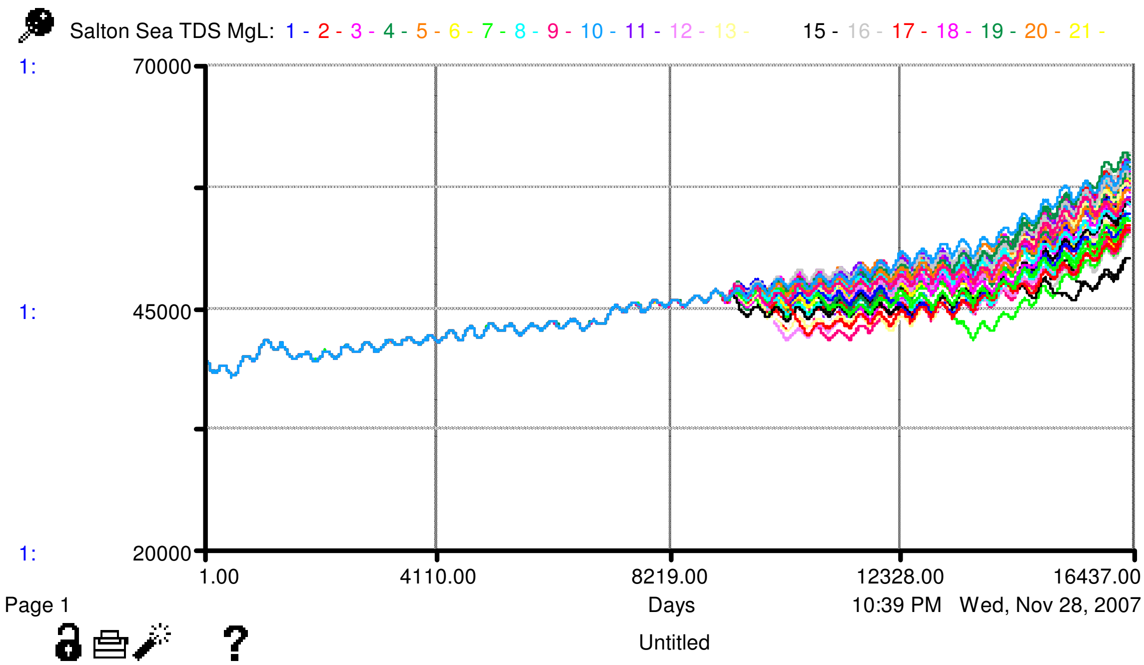


Fig. A.151 - Climate version 2 and precipitation and river flow version 2 (stochastic) - Salton Sea salinity (mg/L) after a ten percent increase in precipitation and river flows while holding evaporation and transpiration constant.

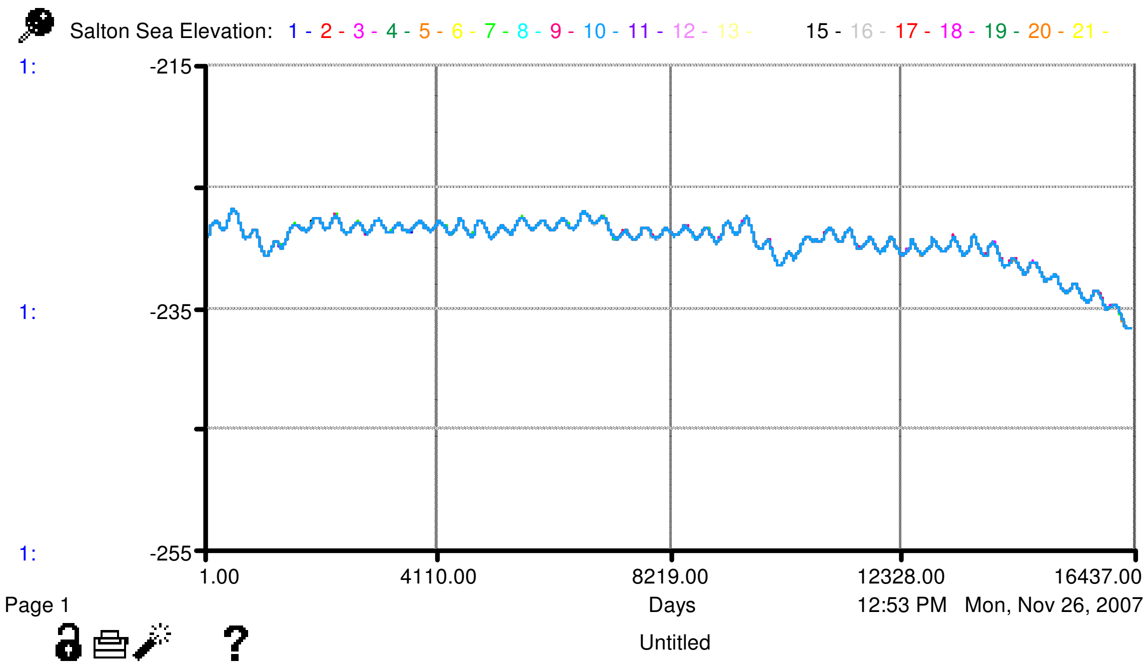


Fig. A.152 - Climate version 3 and precipitation and river flow version 1 (deterministic) - Salton Sea elevation (fasl) after a ten percent decrease in precipitation and river flows while holding evaporation and transpiration constant.

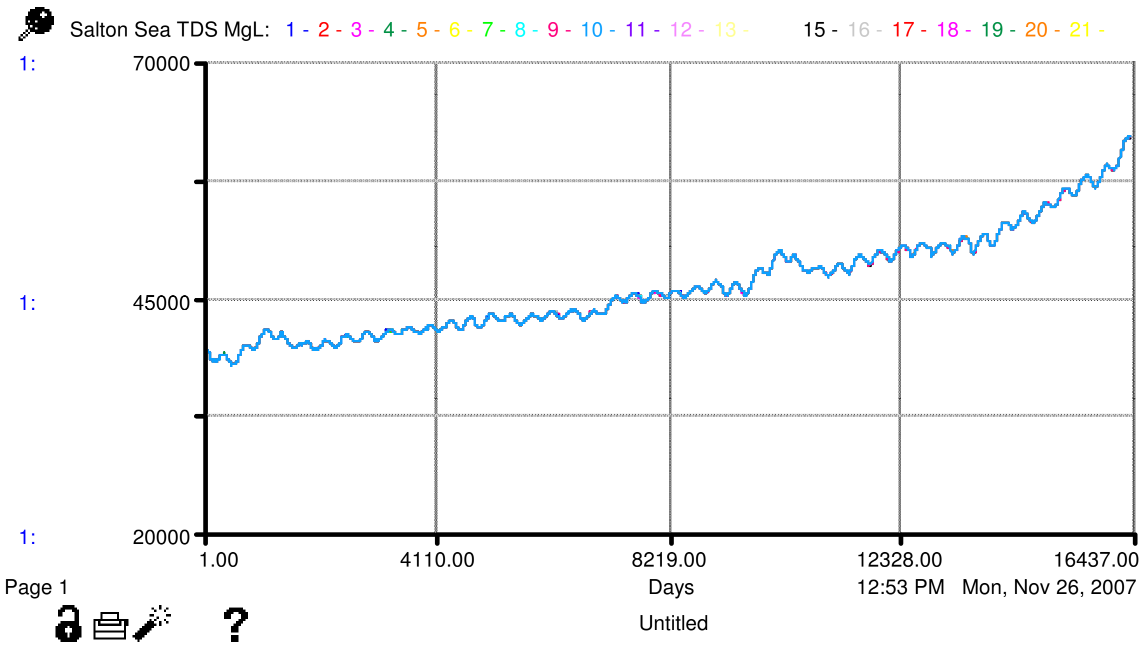


Fig. A.153 - Climate version 3 and precipitation and river flow version 1 (deterministic) - Salton Sea salinity (mg/L) after a ten percent decrease in precipitation and river flows while holding evaporation and transpiration constant.

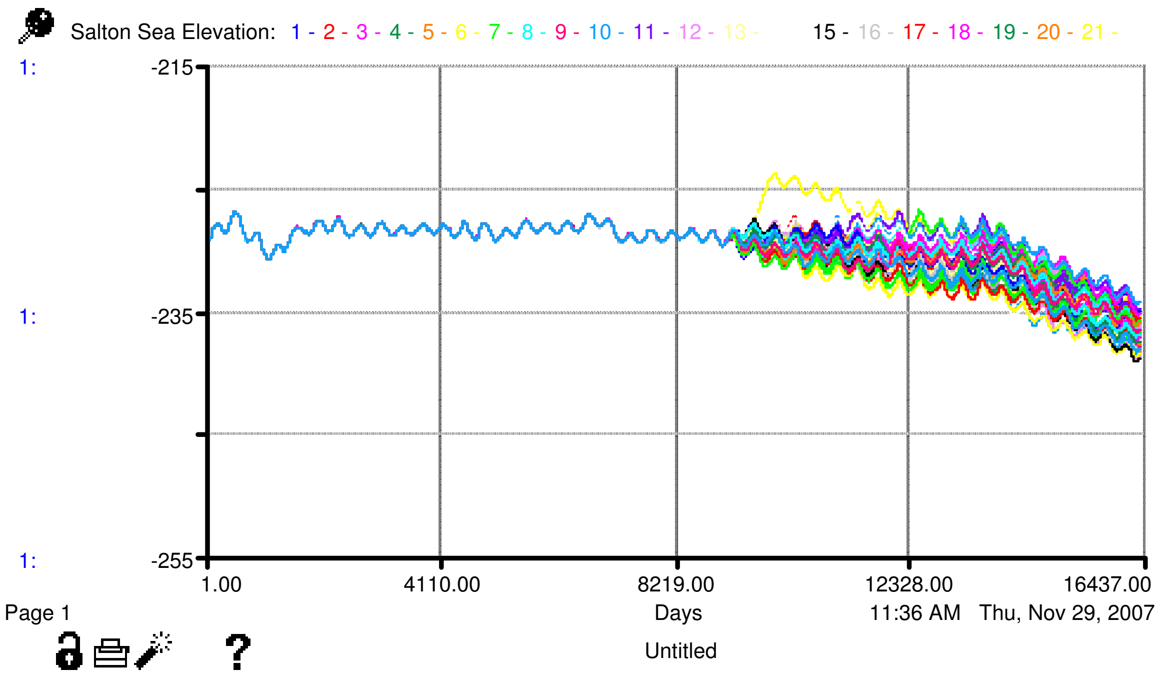


Fig. A.154 - Climate version 3 and precipitation and river flow version 2 (stochastic) - Salton Sea elevation (fasl) after a ten percent decrease in precipitation and river flows while holding evaporation and transpiration constant.

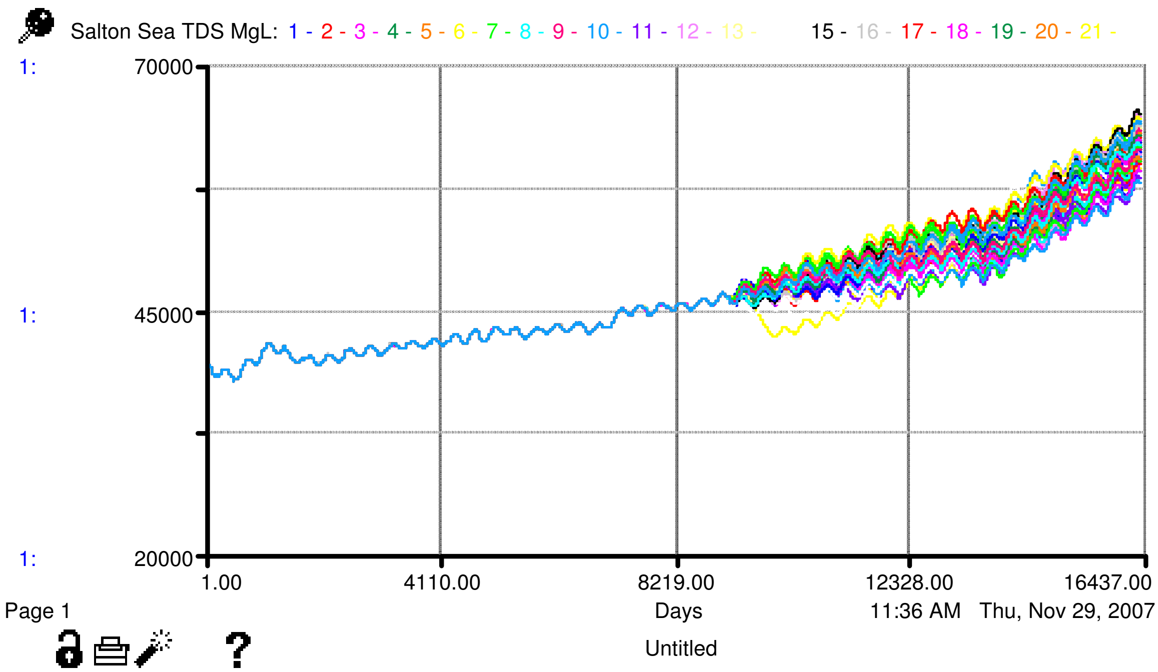


Fig. A.155 - Climate version 3 and precipitation and river flow version 2 (stochastic) - Salton Sea salinity (mg/L) after a ten percent decrease in precipitation and river flows while holding evaporation and transpiration constant.

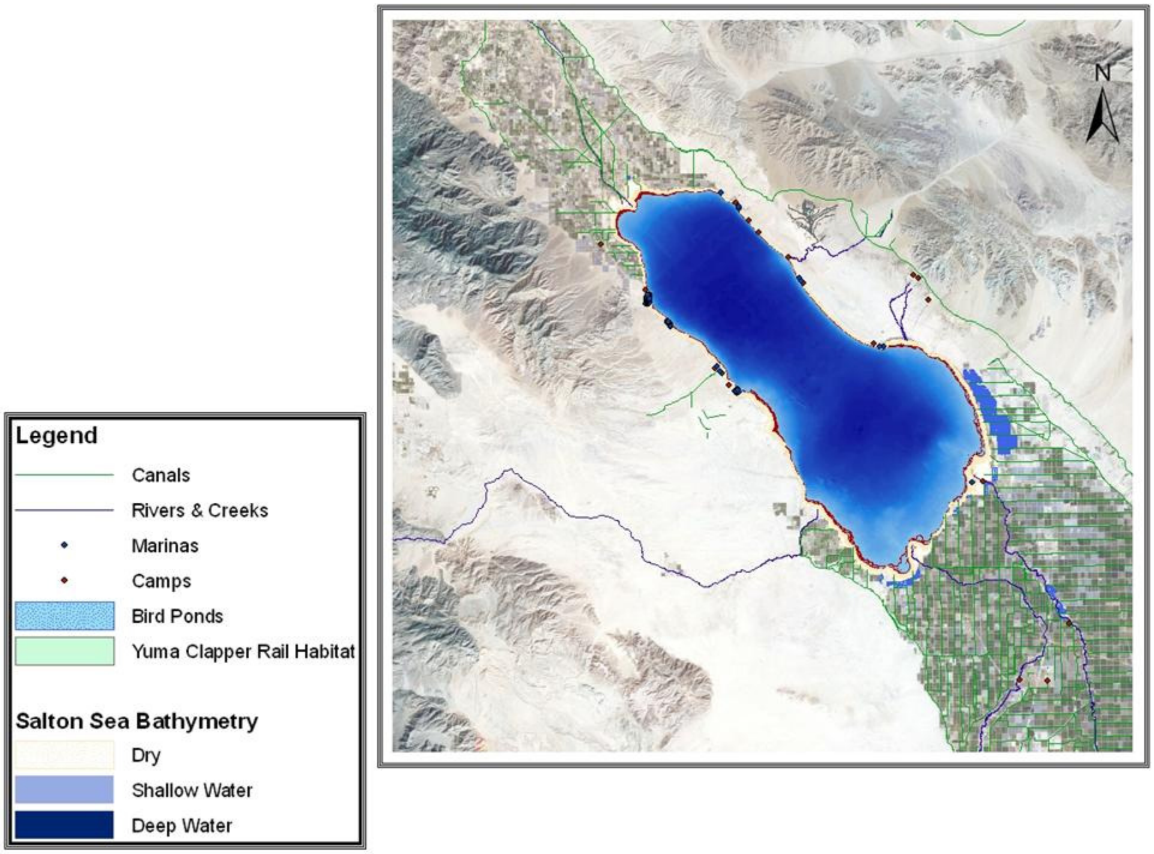


Fig. A.156 - Climate sensitivity analysis results: whole sea deterministic climate -235 avg., -233 max., and -237 min.

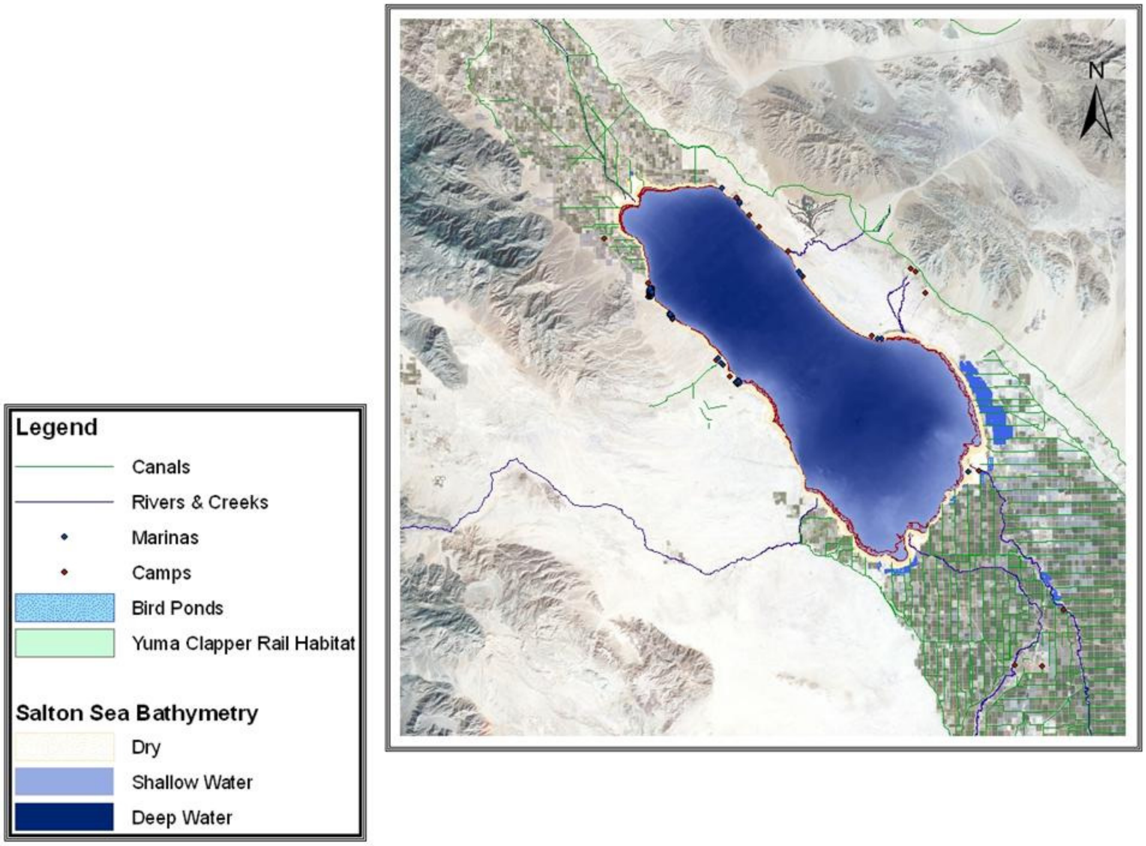


Fig. A.157 - Climate sensitivity analysis results: whole sea stochastic baseline climate -238 min., -235 avg., & -233 max.

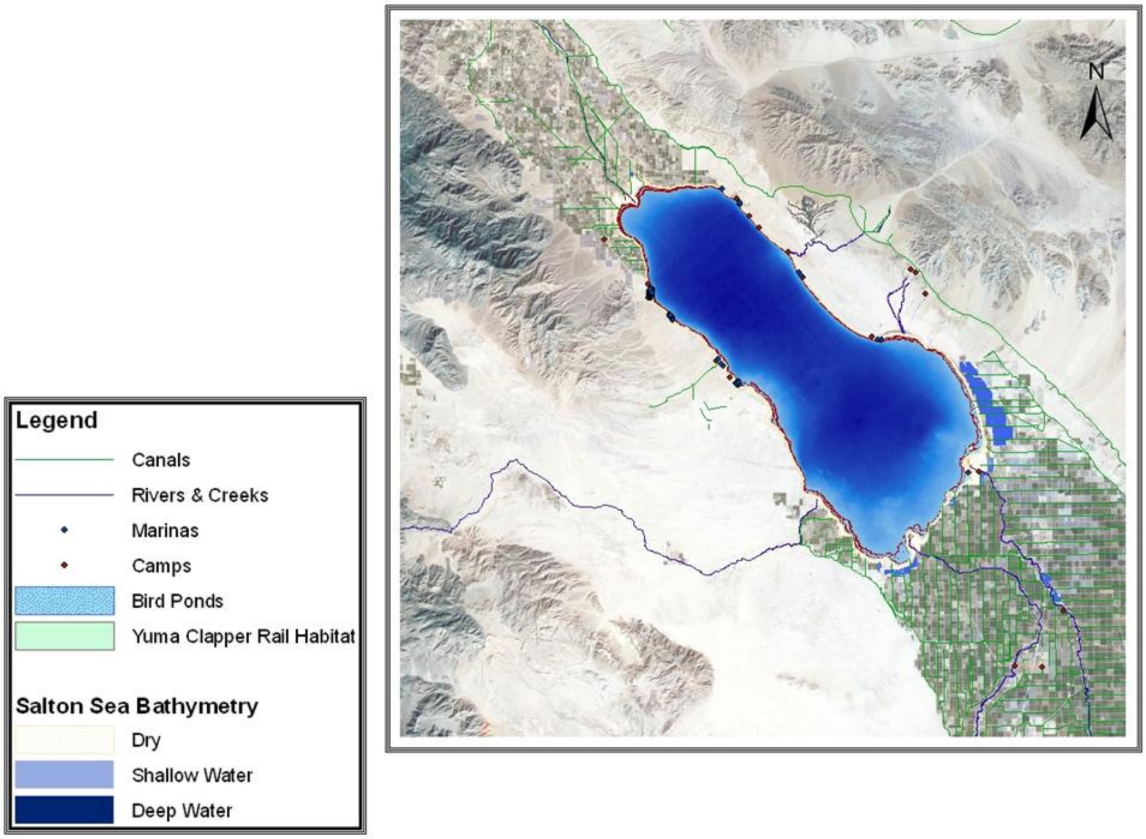


Fig. A.158 - Climate sensitivity analysis results: whole sea stochastic +10% climate -228 max (-233 avg. & -237 min.).

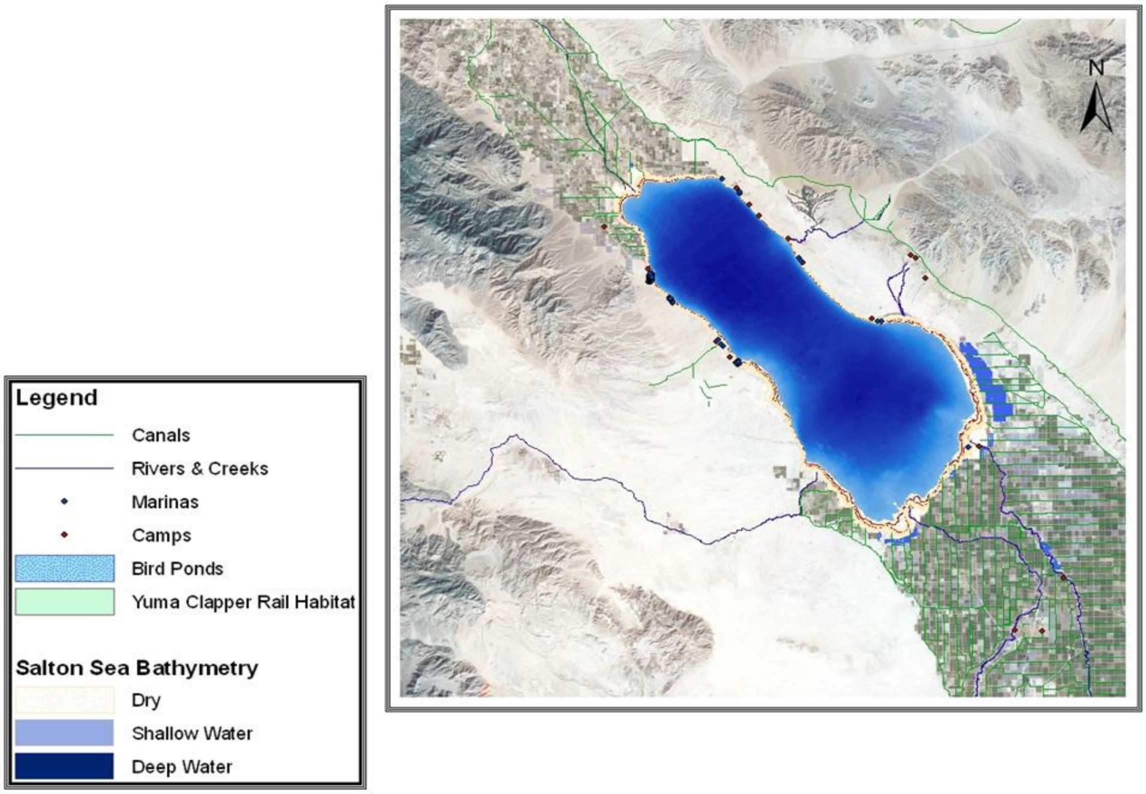


Fig. A.159 - Climate sensitivity analysis results: whole sea stochastic -10% climate -239 min., -237 avg., & -234 max.

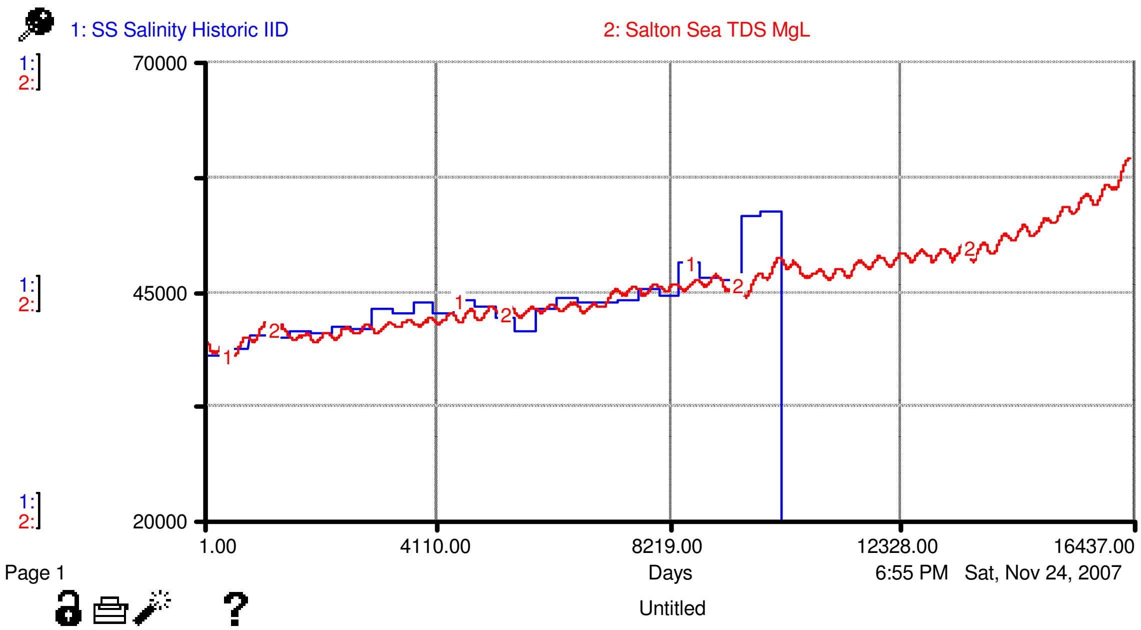


Fig. A.160 - Historic salinity (provisional data for years 2006 and 2007) based on total dissolved solids (TDS) in mg/L versus simulated salinity of the Salton Sea.

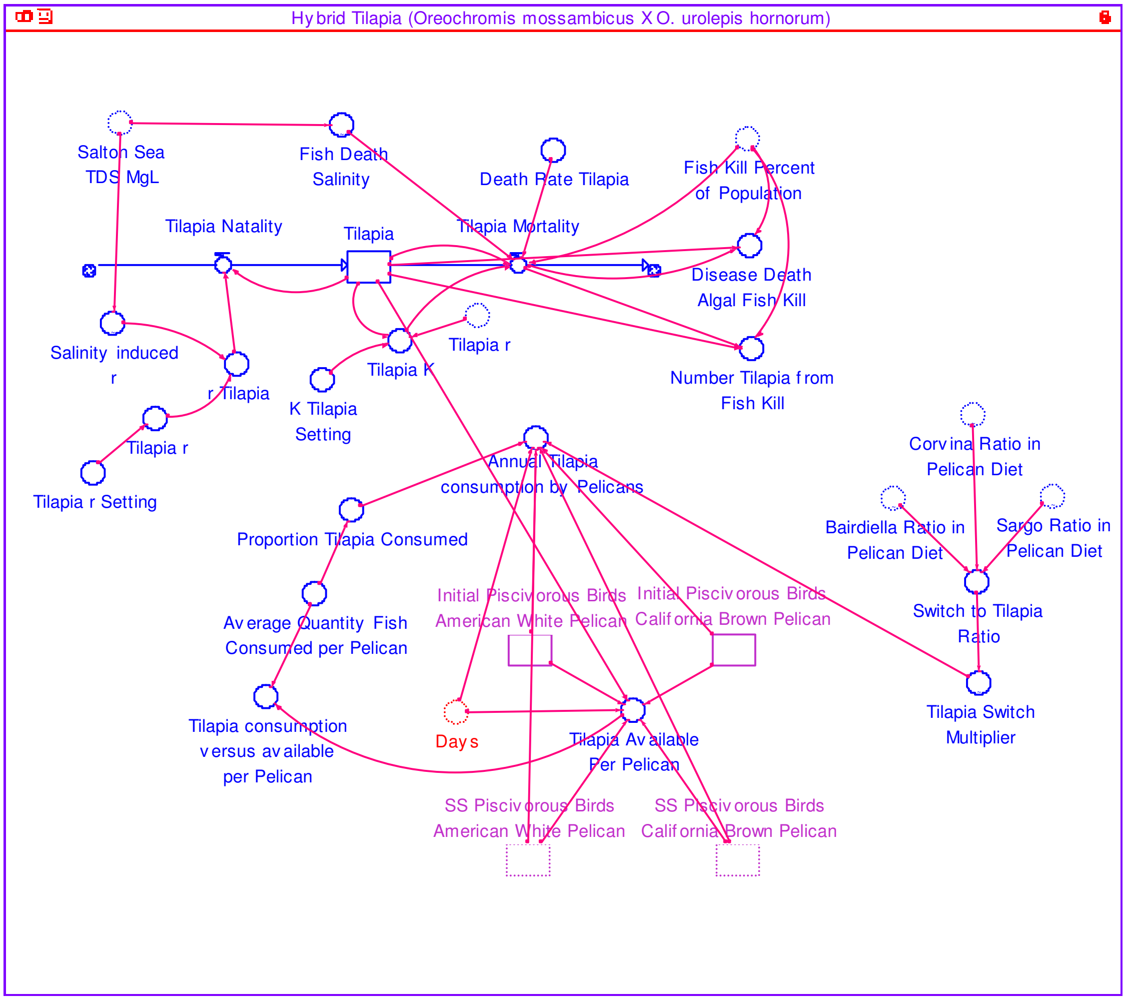


Fig. A.161 - Salton Sea Tilapia sub-model.

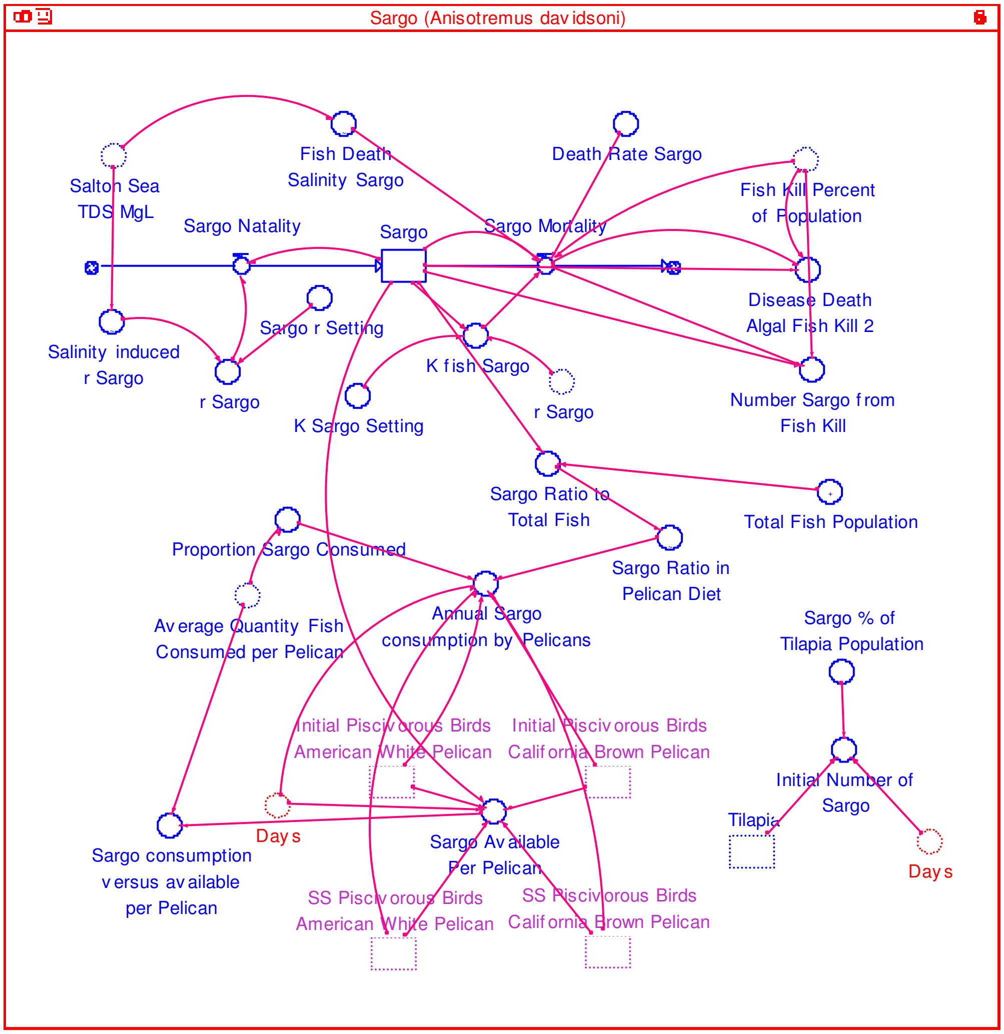


Fig. A.162 - Salton Sea Sargo sub-model.

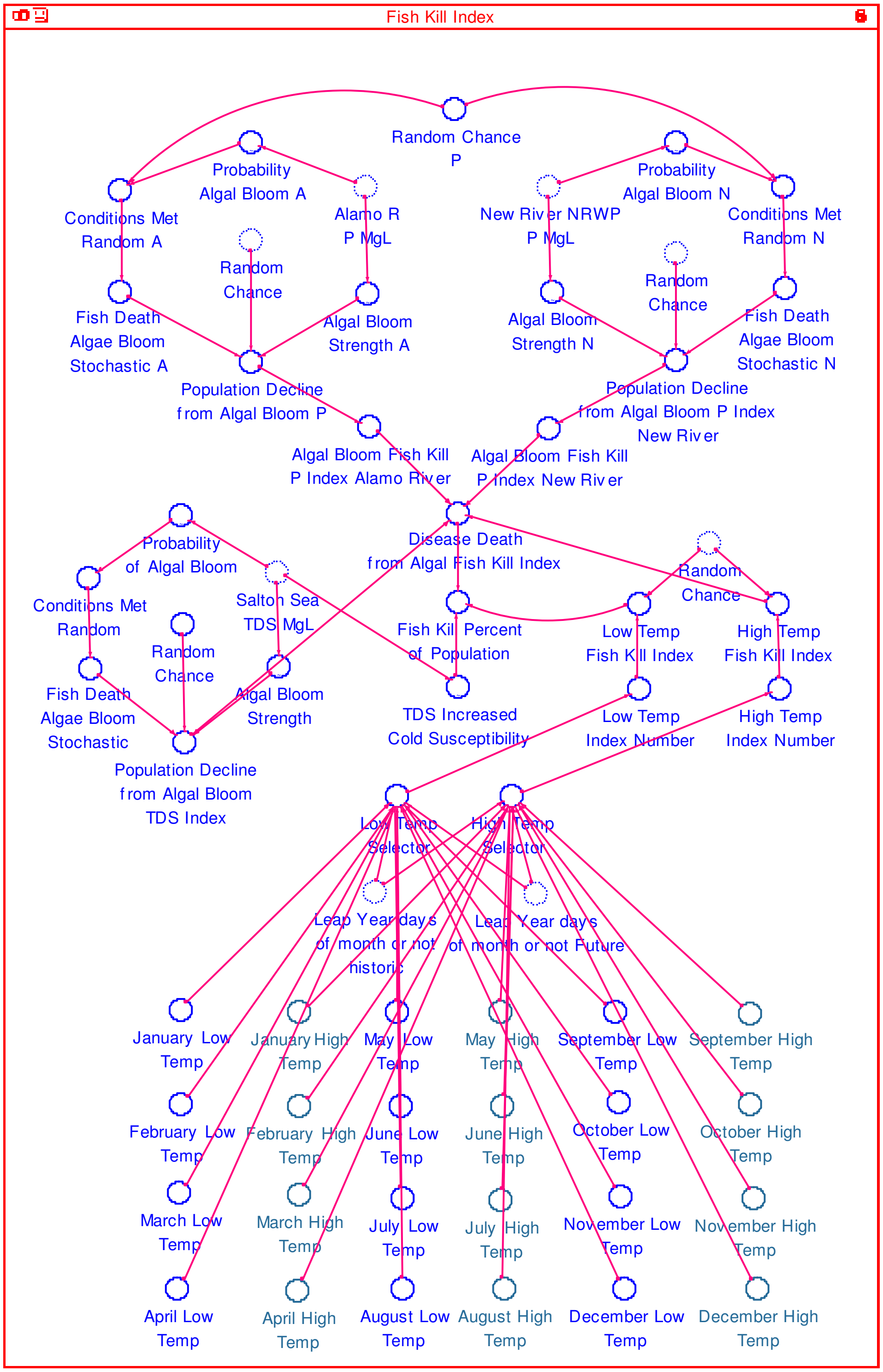


Fig. A.163 - Fish kill index sub-model.

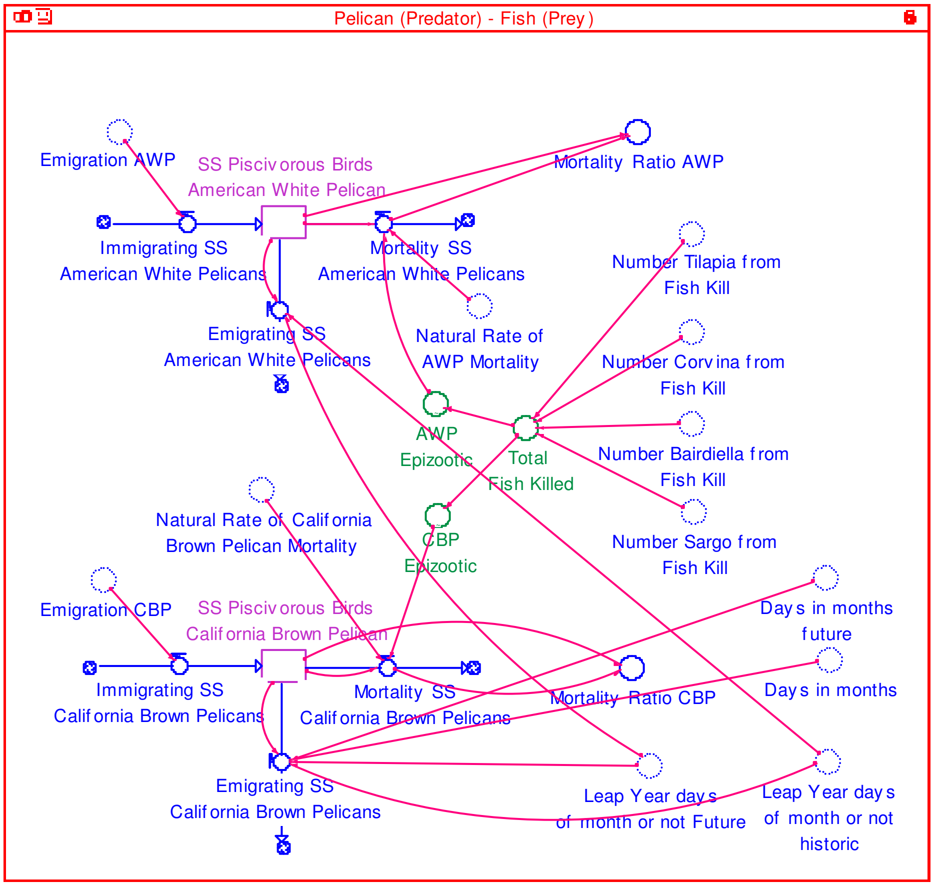


Fig. A.164 - Salton Sea AWP and CBP populations sub-model.

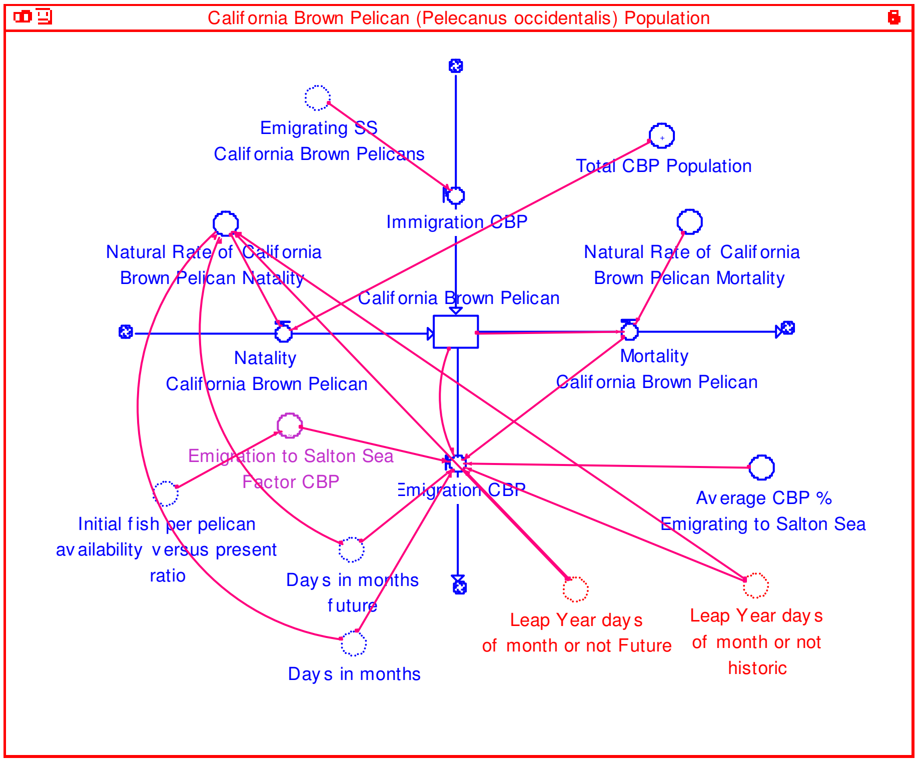


Fig. A.165 - California Brown Pelican sub-model.

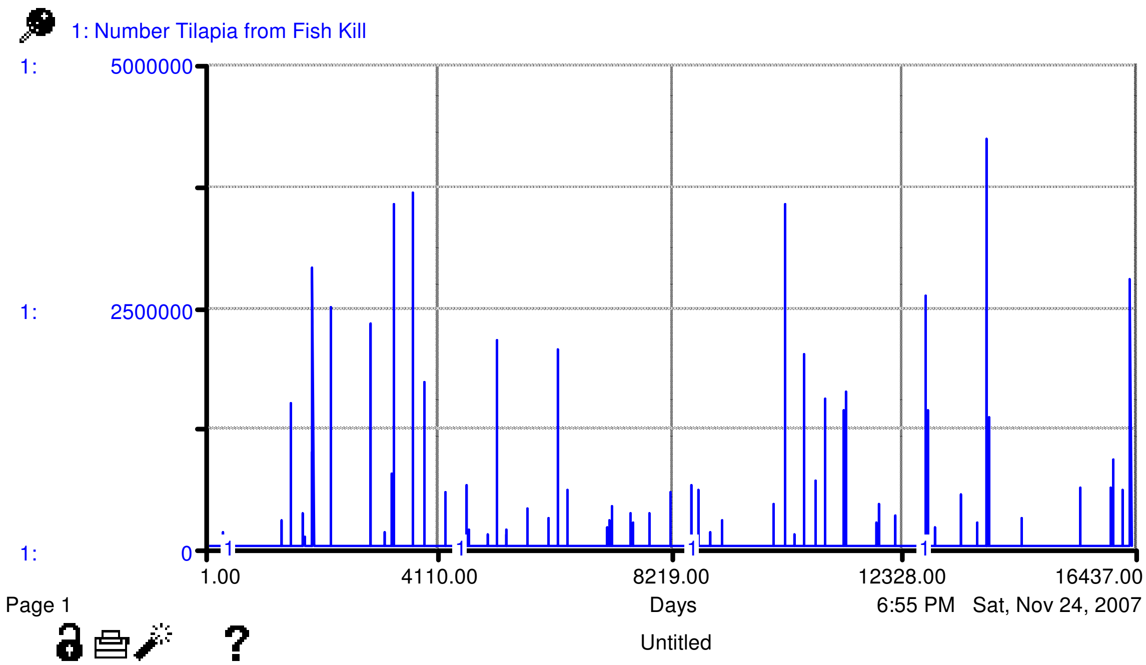


Fig. A.166 - Baseline 1 (strategy 1): Salton Sea Tilapia die-off numbers (1980 - 2024).

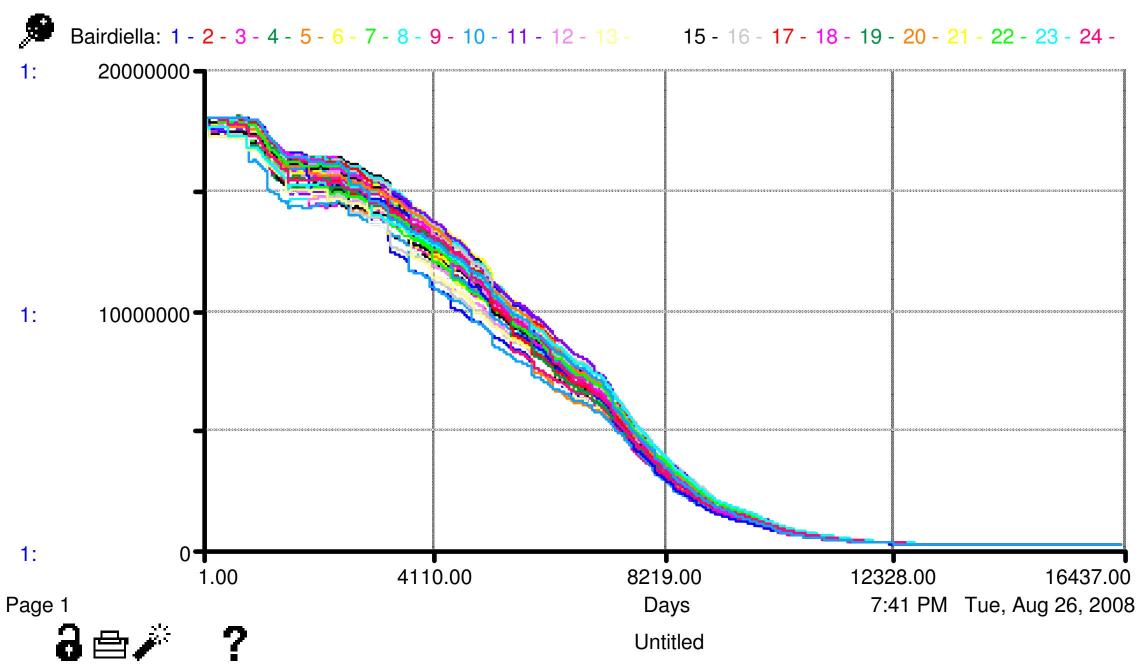


Fig. A.167 - Baseline 1 (strategy 1): Salton Sea Croaker population (1980 - 2024).

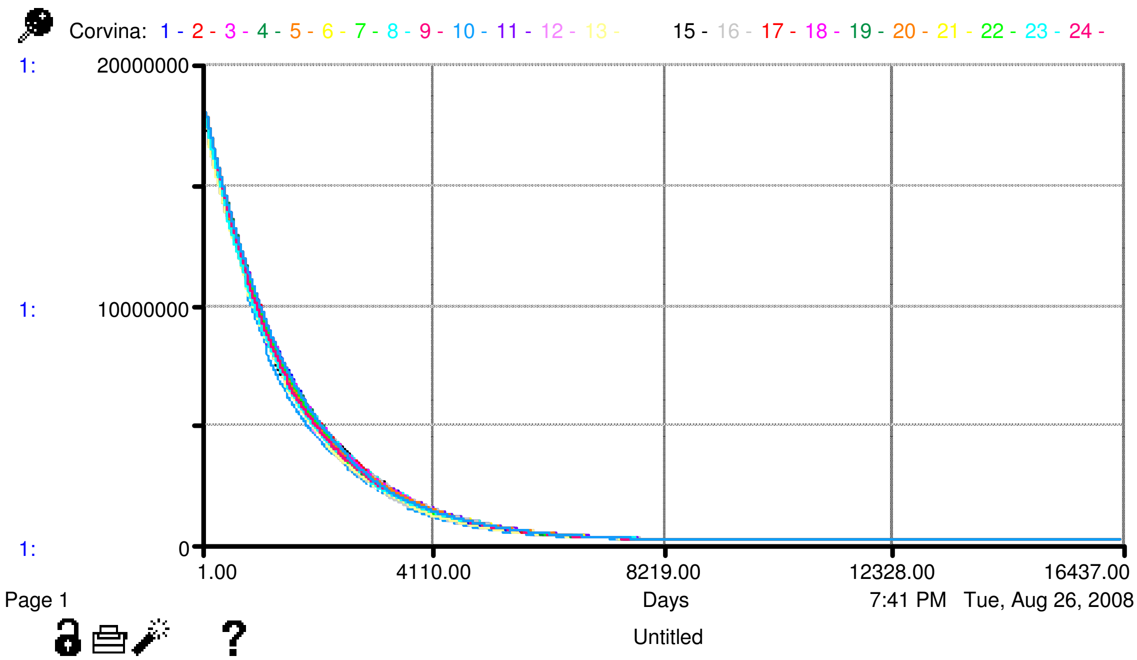


Fig. A.168 - Baseline 1 (strategy 1): Salton Sea Corvina population (1980 - 2024).

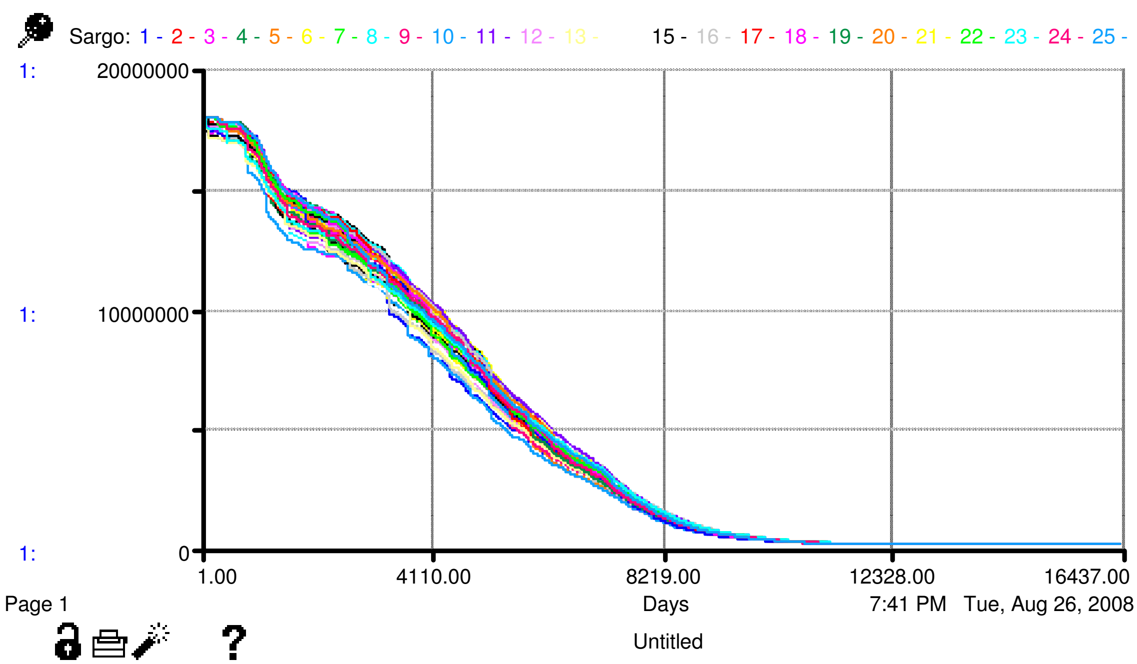


Fig. A.169 - Baseline 1 (strategy 1): Salton Sea Sargo population (1980 - 2024).

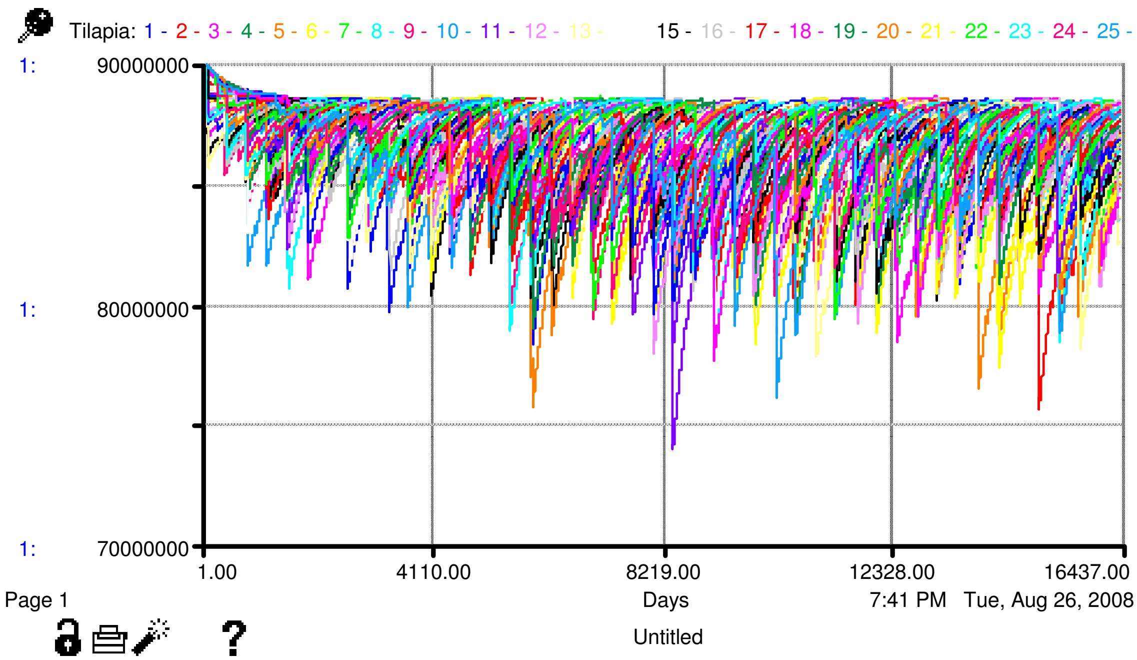


Fig. A.170 - Baseline 1 (strategy 1): Salton Sea Tilapia population (1980 - 2024).

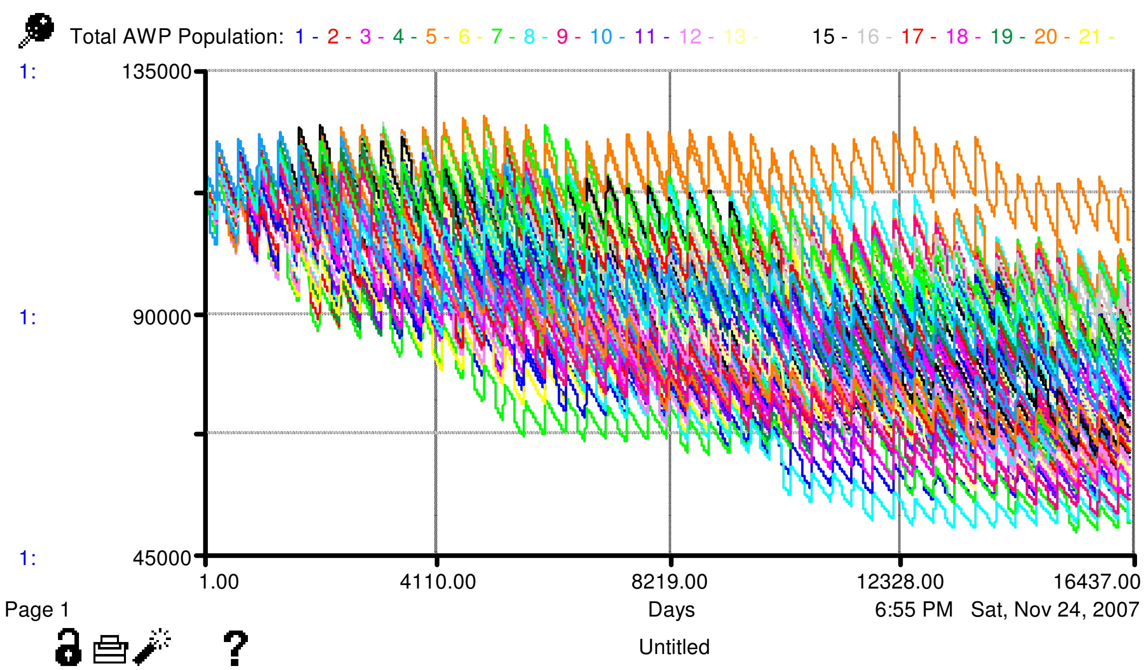


Fig. A.171 - Baseline 1 (strategy 1): continental AWP population (1980 - 2024).

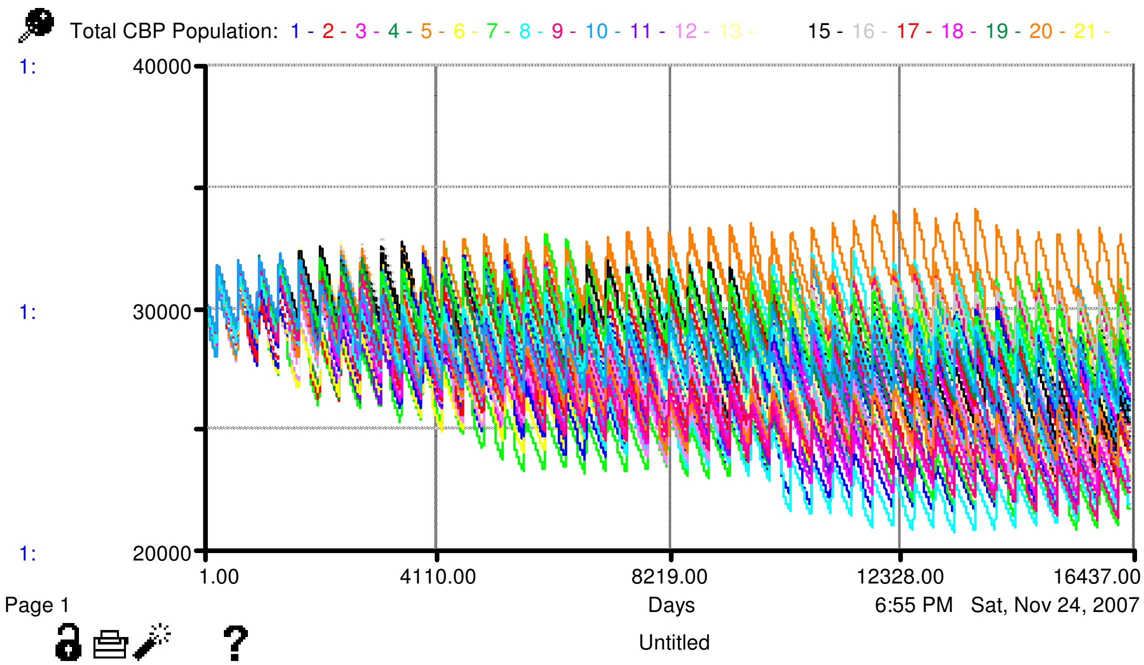


Fig. A.172 - Baseline 1 (strategy 1): continental CBP population (1980 - 2024).

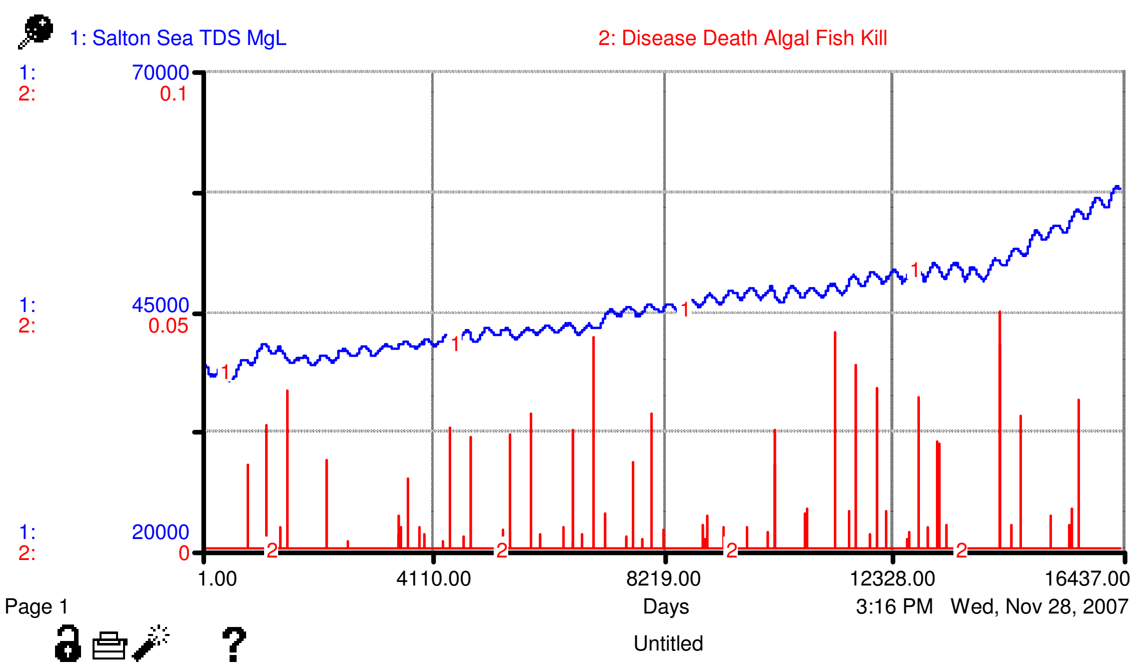


Fig. A.173 - Baseline 2 (strategy 2): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

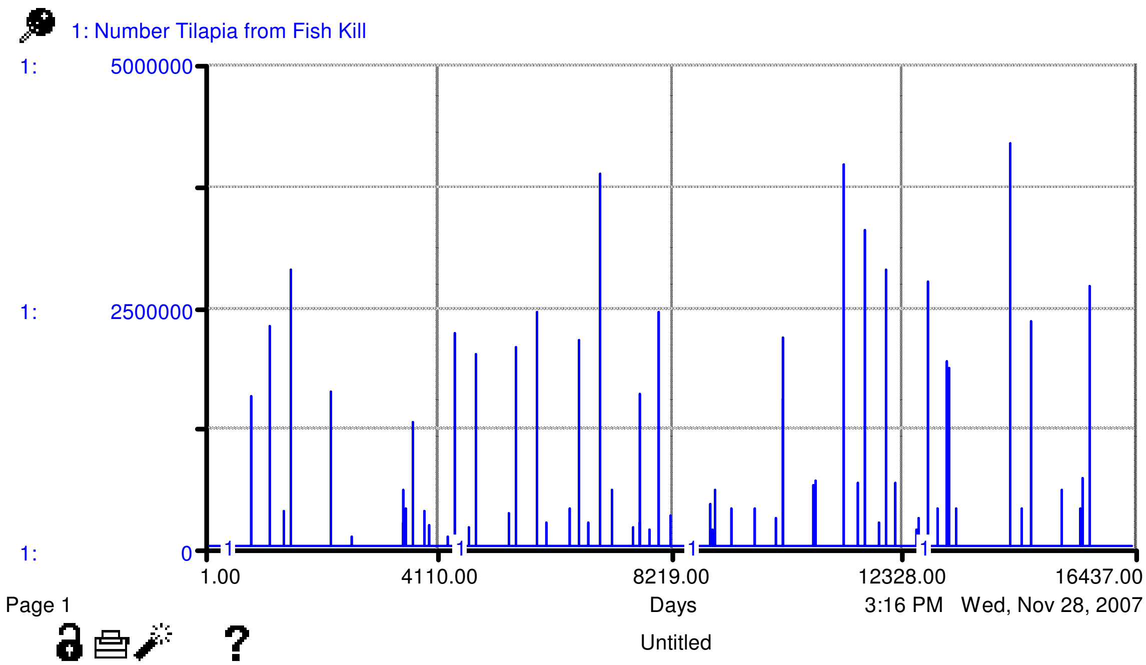


Fig. A.174 - Baseline 2 (strategy 2): Salton Sea Tilapia die-off numbers (1980 - 2024).

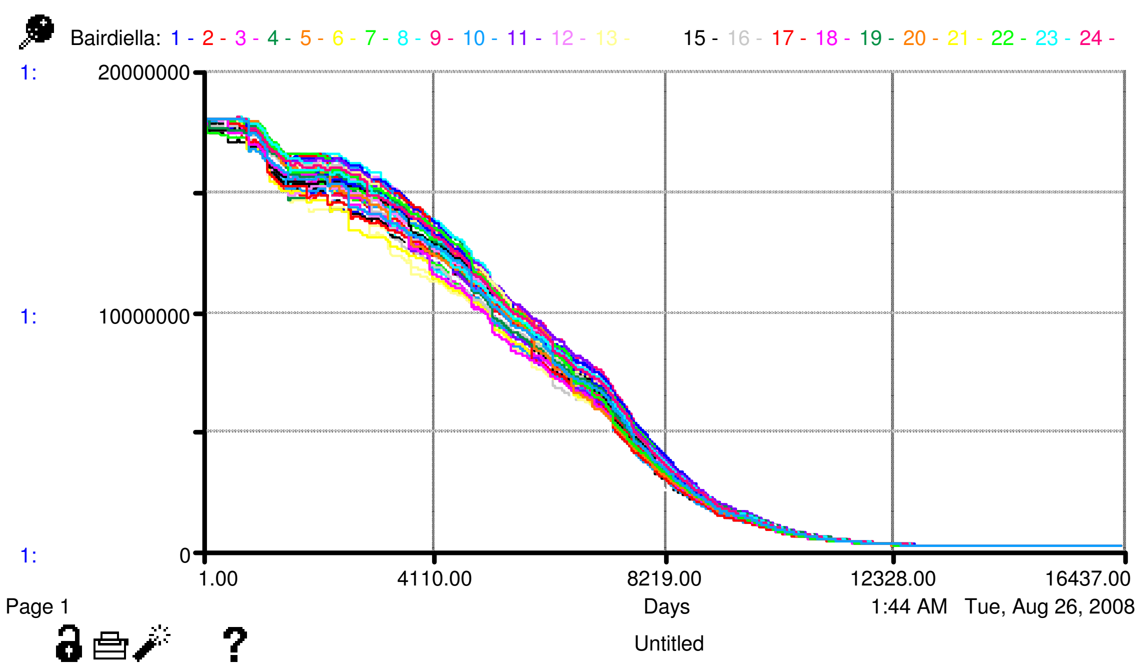


Fig. A.175 - Baseline 2 (strategy 2): Salton Sea Croaker population (1980 - 2024).

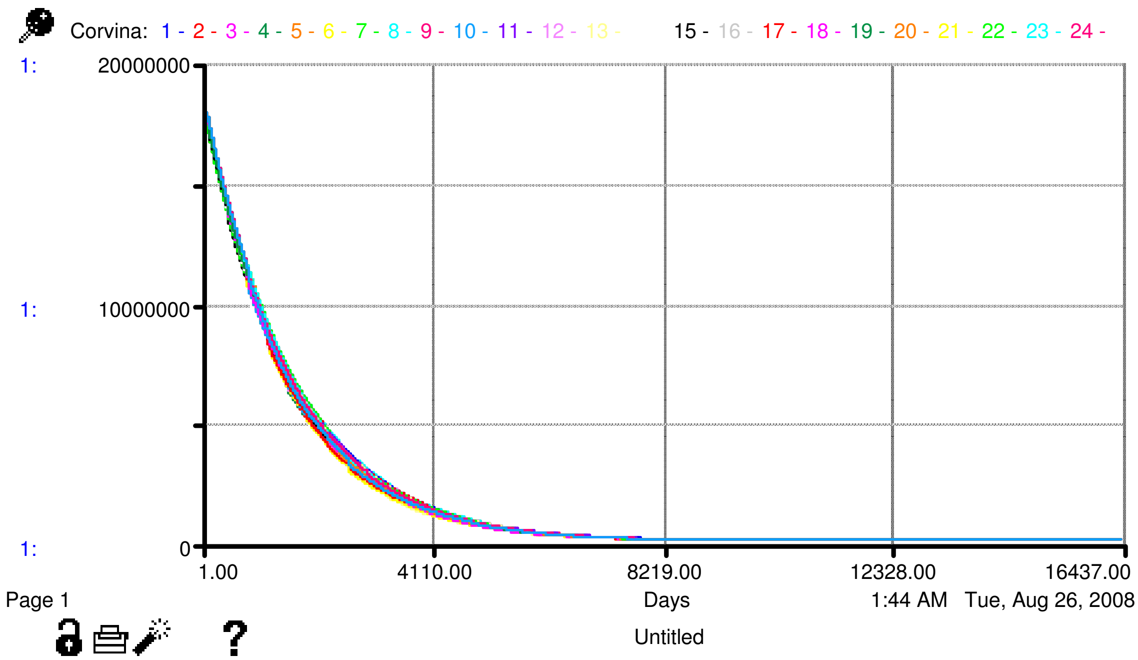


Fig. A.176 - Baseline 2 (strategy 2): Salton Sea Corvina population (1980 - 2024).

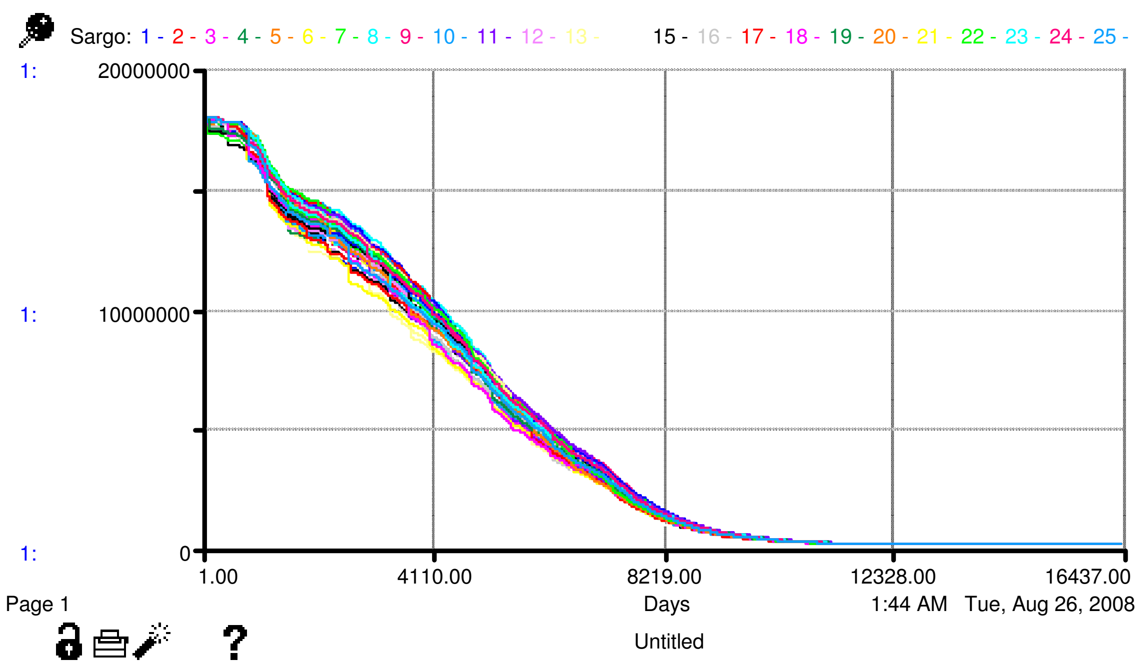


Fig. A.177 - Baseline 2 (strategy 2): Salton Sea Sargo population (1980 - 2024).

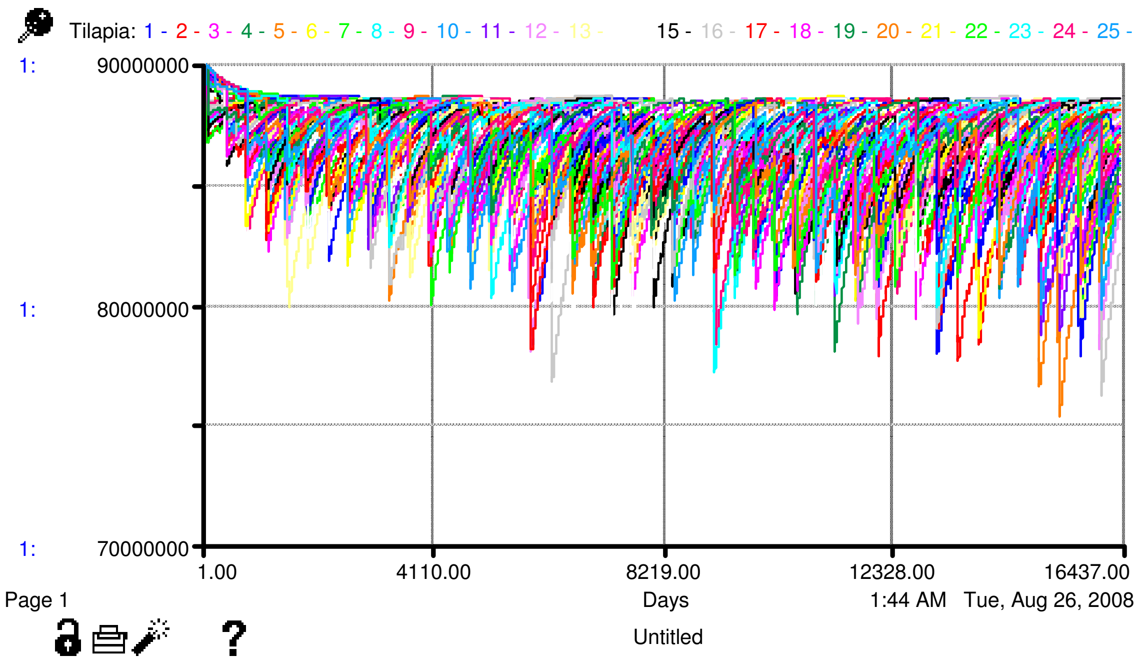


Fig. A.178 - Baseline 2 (strategy 2): Salton Sea Tilapia population (1980 - 2024).

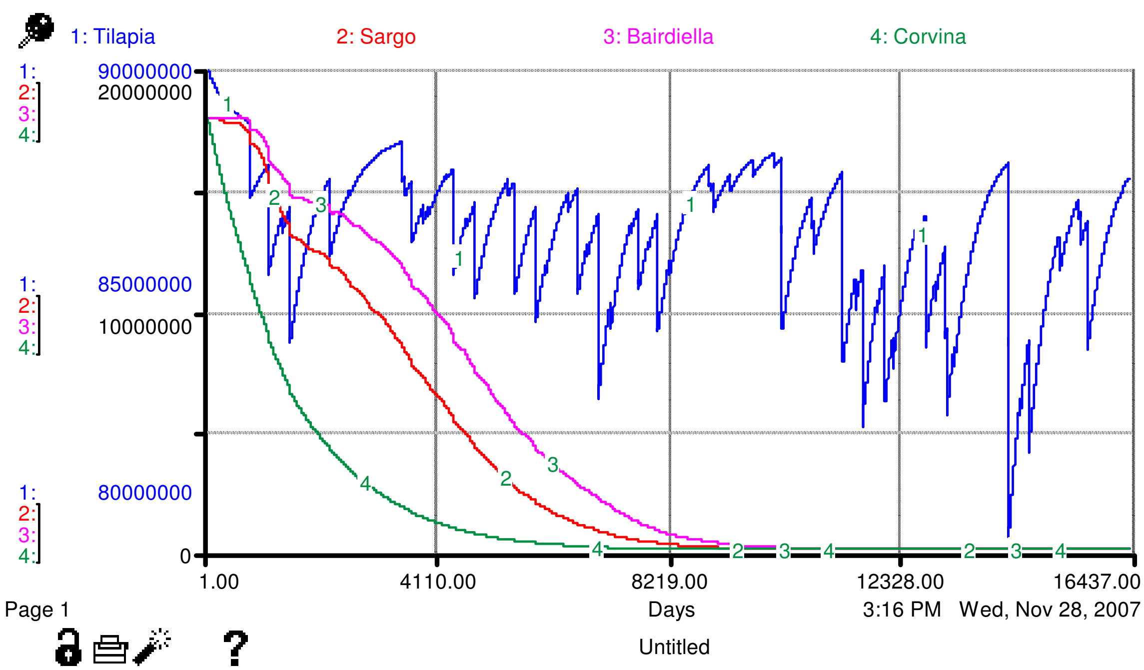


Fig. A.179 - Baseline 2 (strategy 2): Salton Sea fish species' population comparison (1980 - 2024).

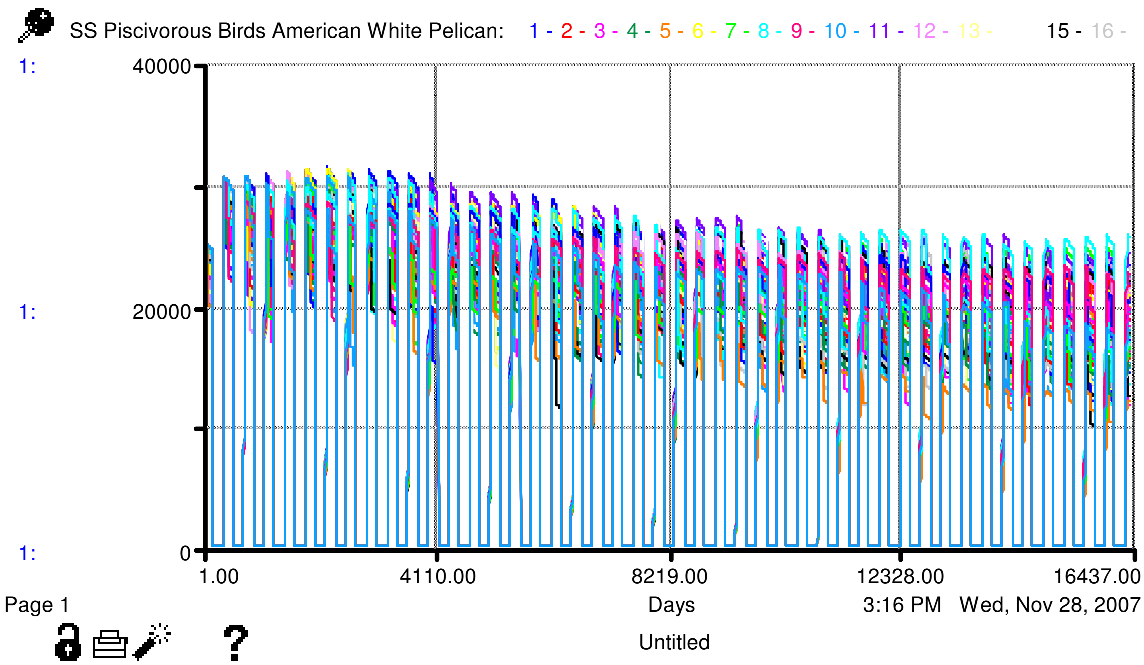


Fig. A.180 - Baseline 2 (strategy 2): Salton Sea AWP population (1980 - 2024).

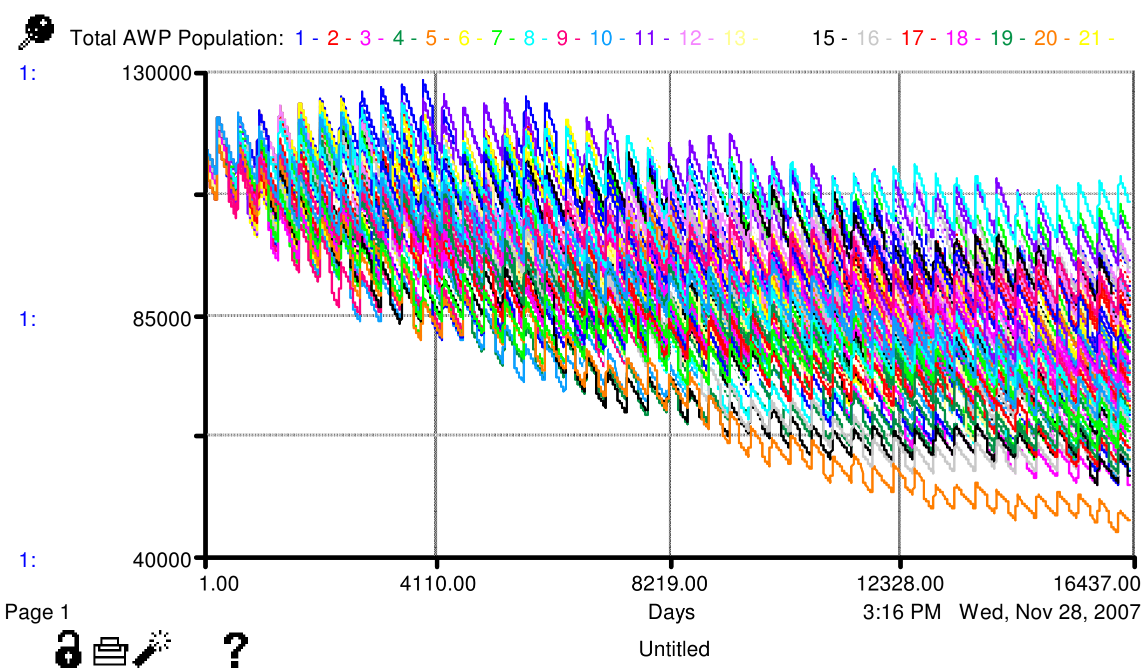


Fig. A.181 - Baseline 2 (strategy 2): continental AWP population (1980 - 2024).

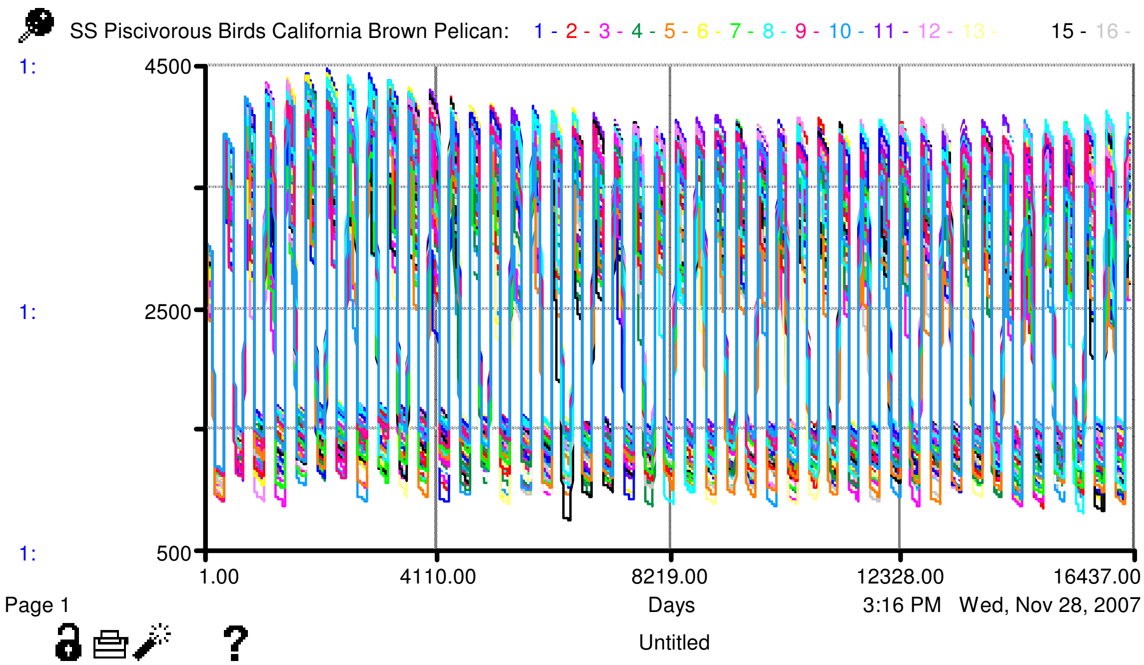


Fig. A.182 - Baseline 2 (strategy 2): Salton Sea CBP population (1980 - 2024).

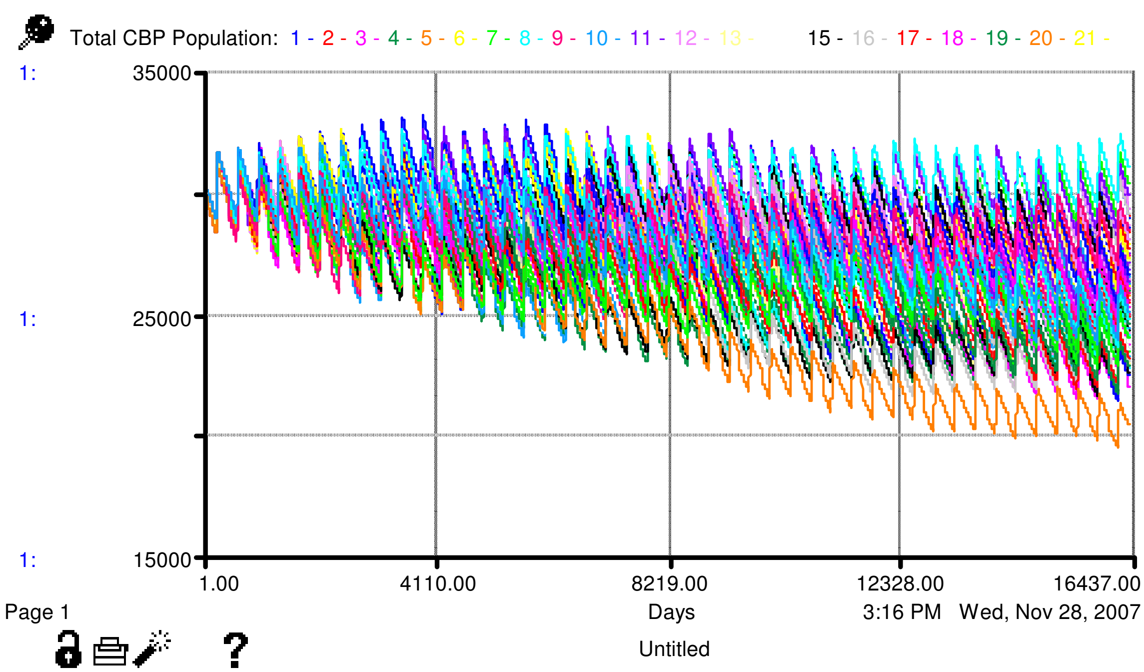


Fig. A.183 - Baseline 2 (strategy 2): continental CBP population (1980 - 2024).

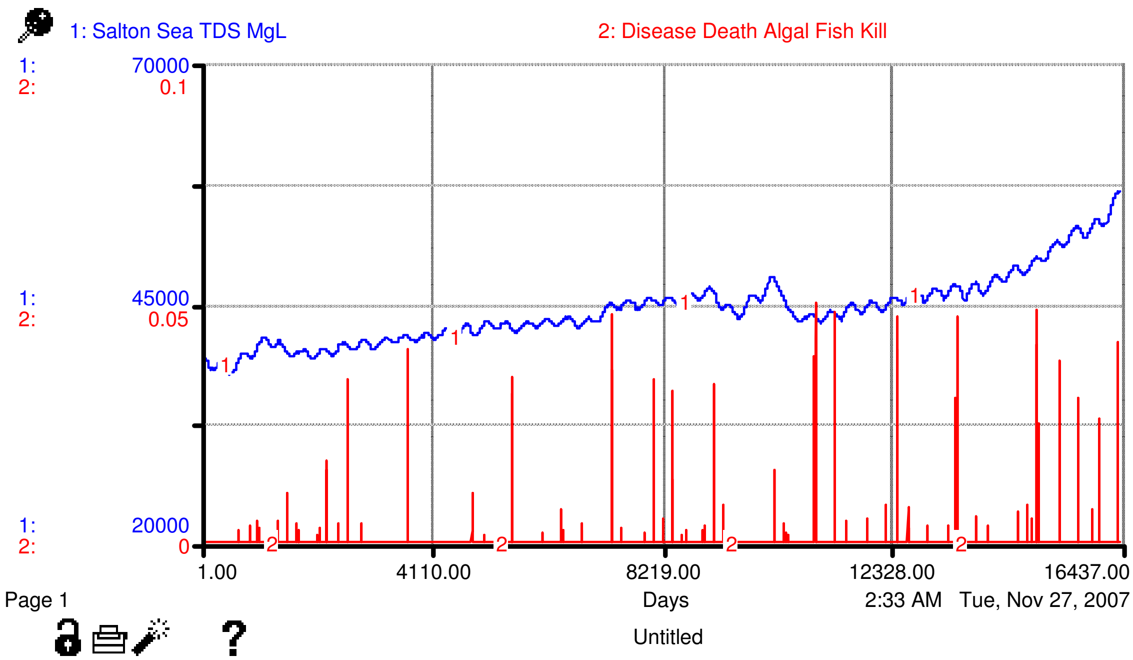


Fig. A.184 - Climate sensitivity analysis (strategy 1) scenario 2 (+10%): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

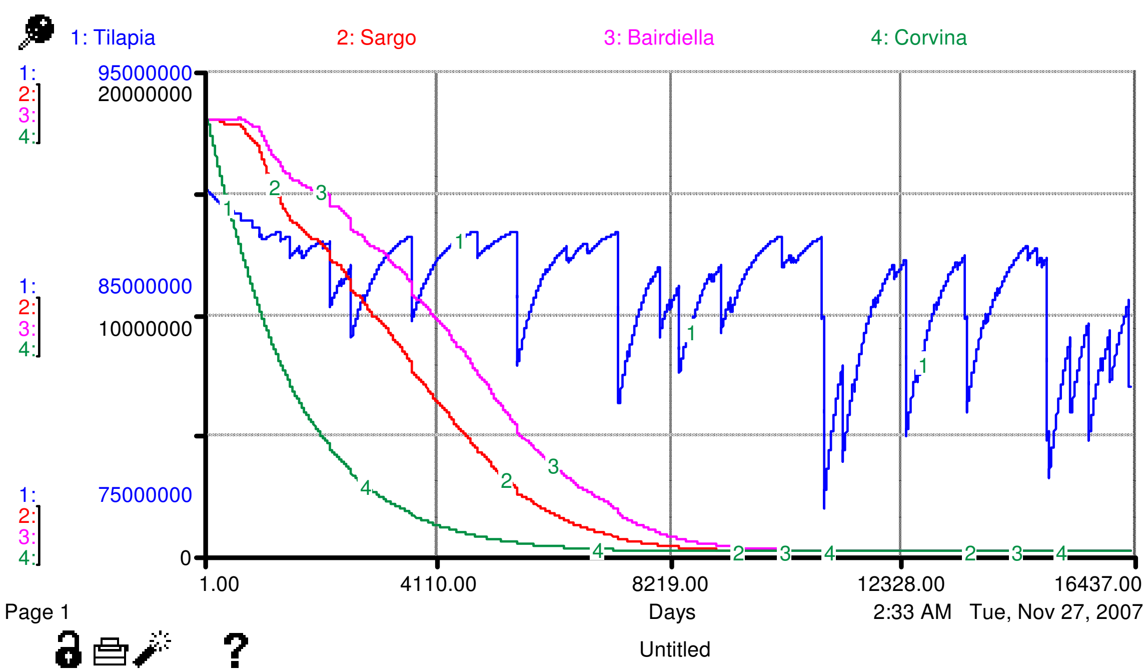


Fig. A.185 - Climate sensitivity analysis (strategy 1) scenario 2 (+10%): Salton Sea fish species' population comparison (1980 - 2024).

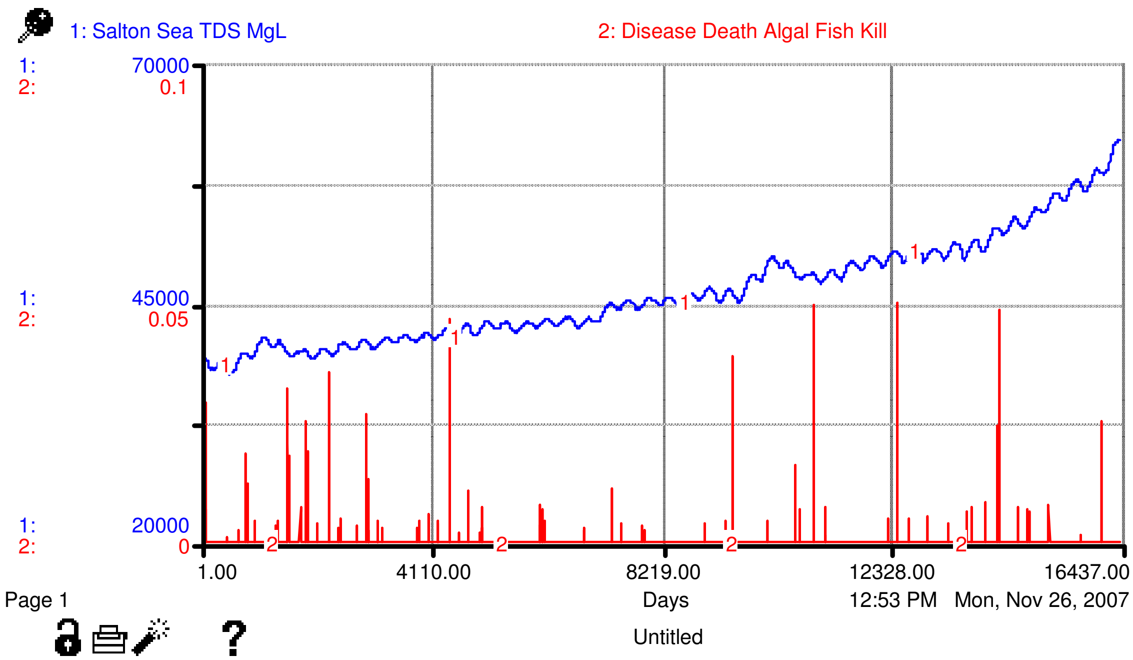


Fig. A.186 - Climate sensitivity analysis (strategy 1) scenario 3 (-10%): Salton Sea salinity (mg/L) and fish kills, magnitude and frequency (1980 - 2024).

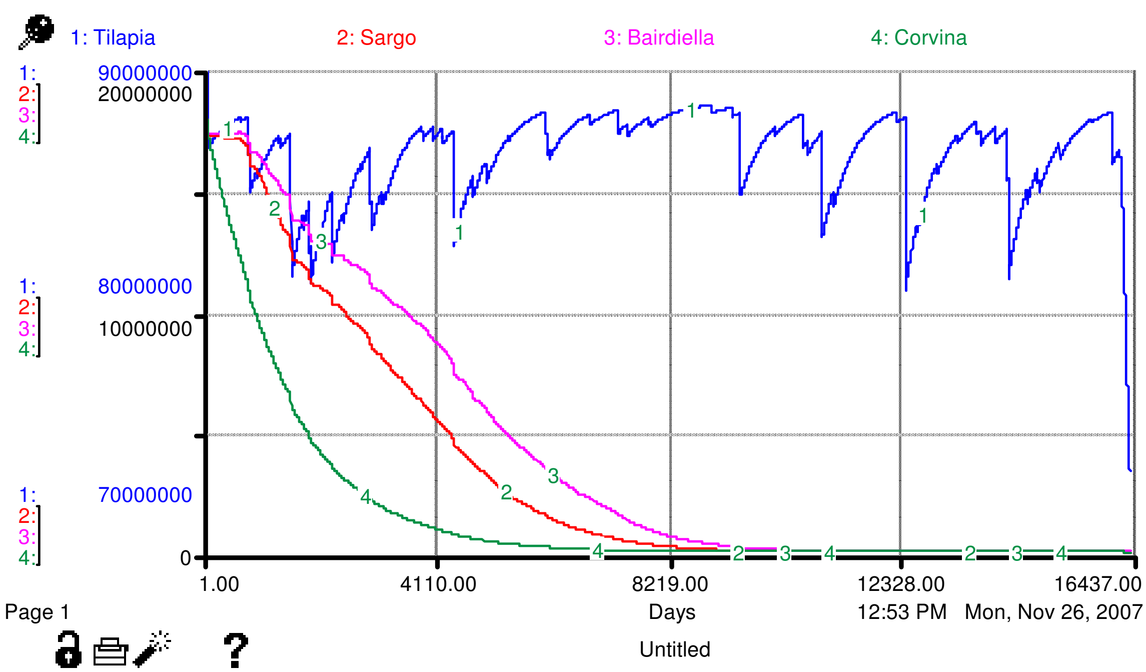


Fig. A.187 - Climate sensitivity analysis (strategy 1) scenario 3 (-10%): Salton Sea fish species' population comparison (1980 - 2024).

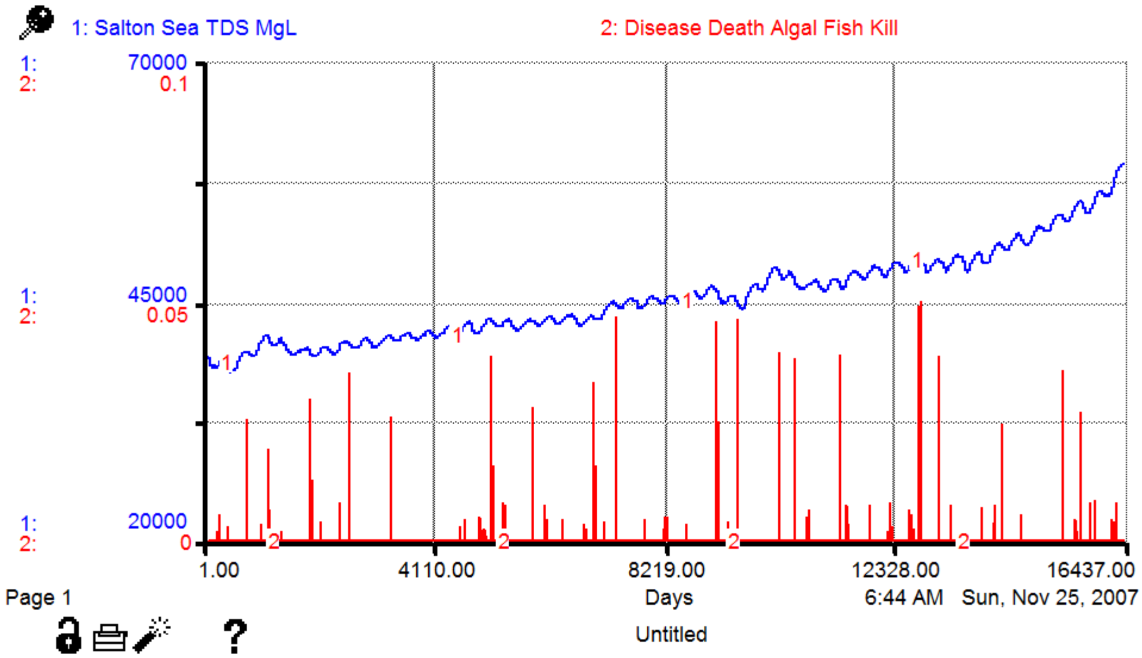


Fig. A.188 - Fish kill sensitivity analysis (strategy 1), ten percent increase: 1) Salton Sea salinity (TDS in mg/L) and 2) size and frequency of fish kill events.

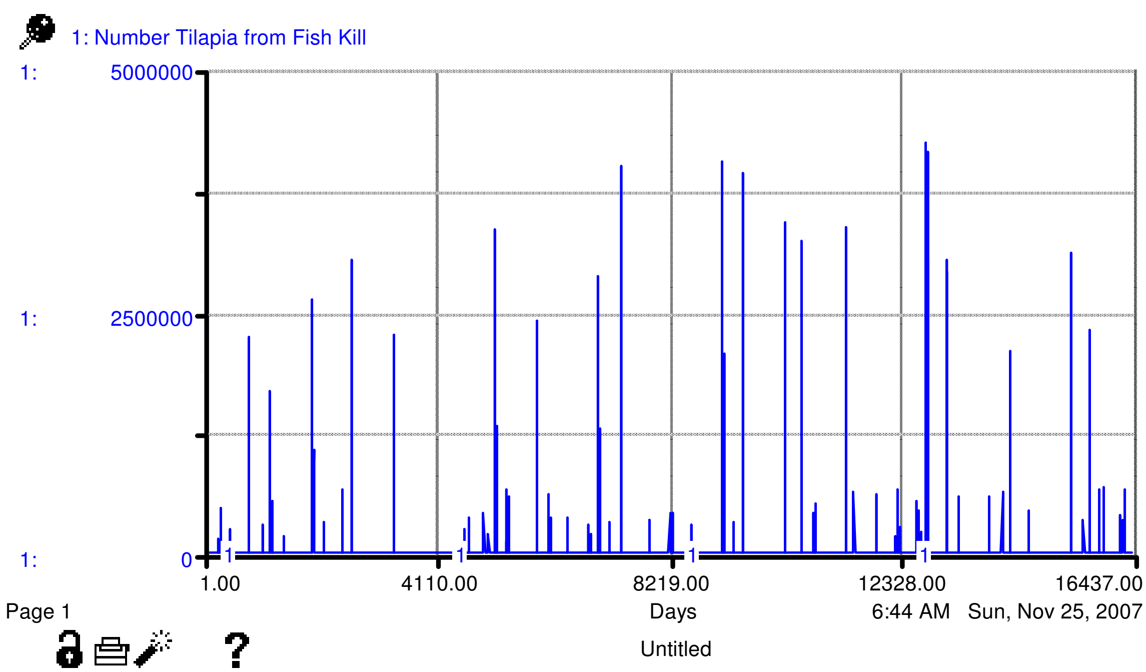


Fig. A.189 - Fish kill sensitivity analysis (strategy 1), ten percent increase: number of Tilapia killed during fish kill events.

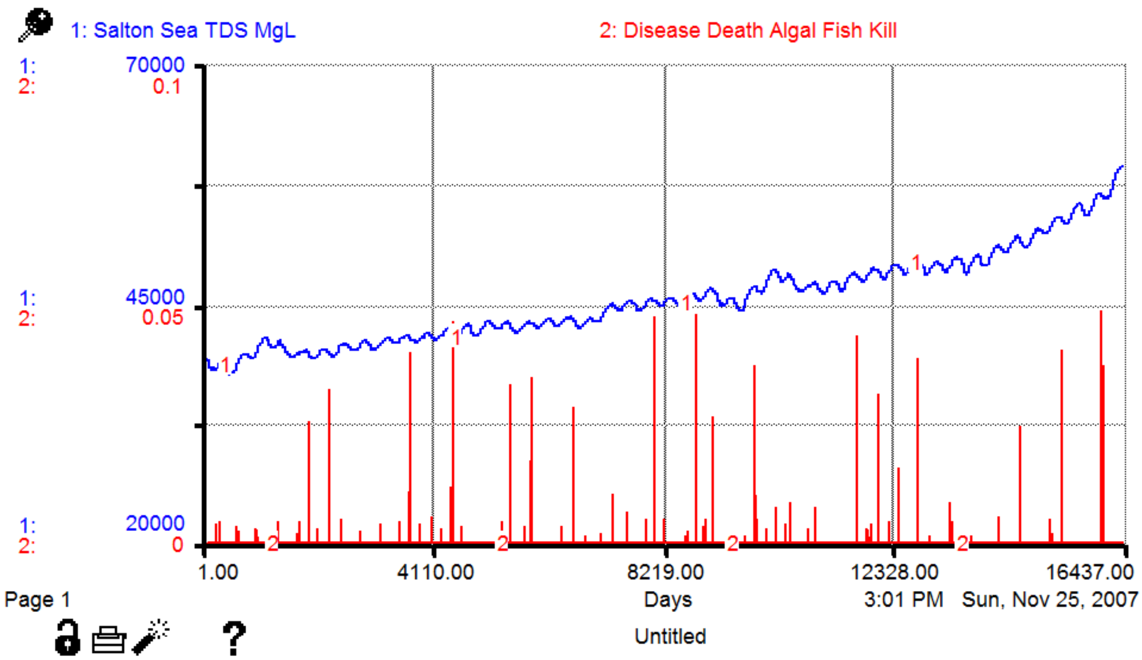


Fig. A.190 - Fish kill sensitivity analysis (strategy 1), ten percent decrease: 1) Salton Sea salinity (TDS in mg/L) and 2) size and frequency of fish kill events.

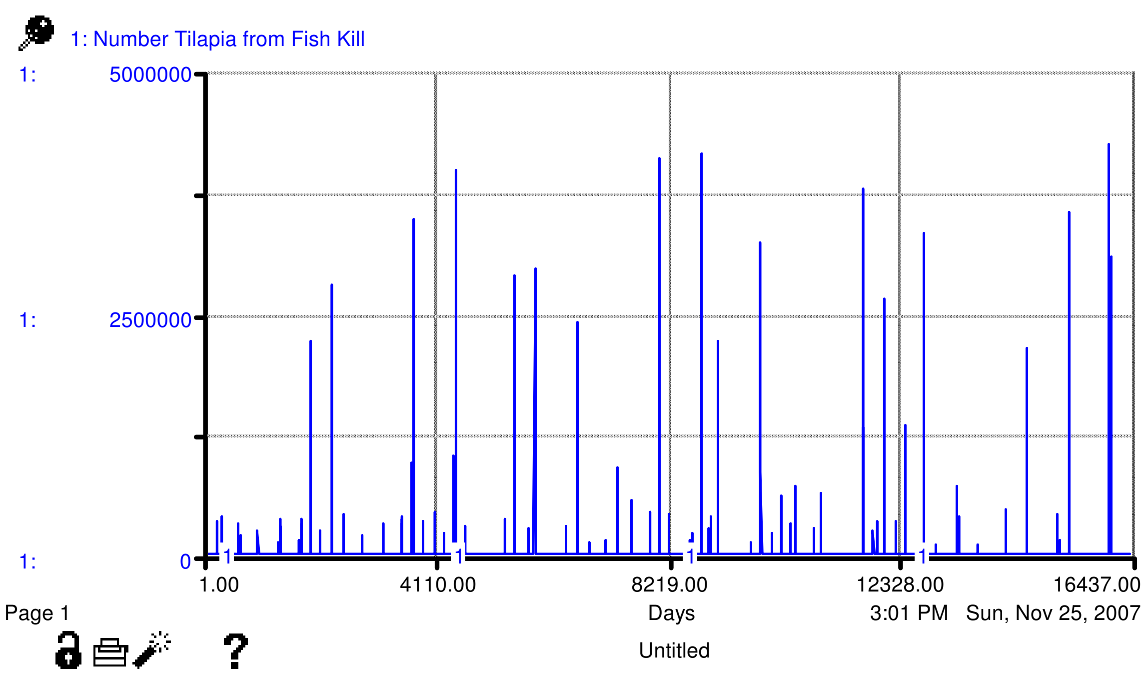


Fig. A.191 - Fish kill sensitivity analysis (strategy 1), ten percent decrease: number of Tilapia killed during fish kill events.

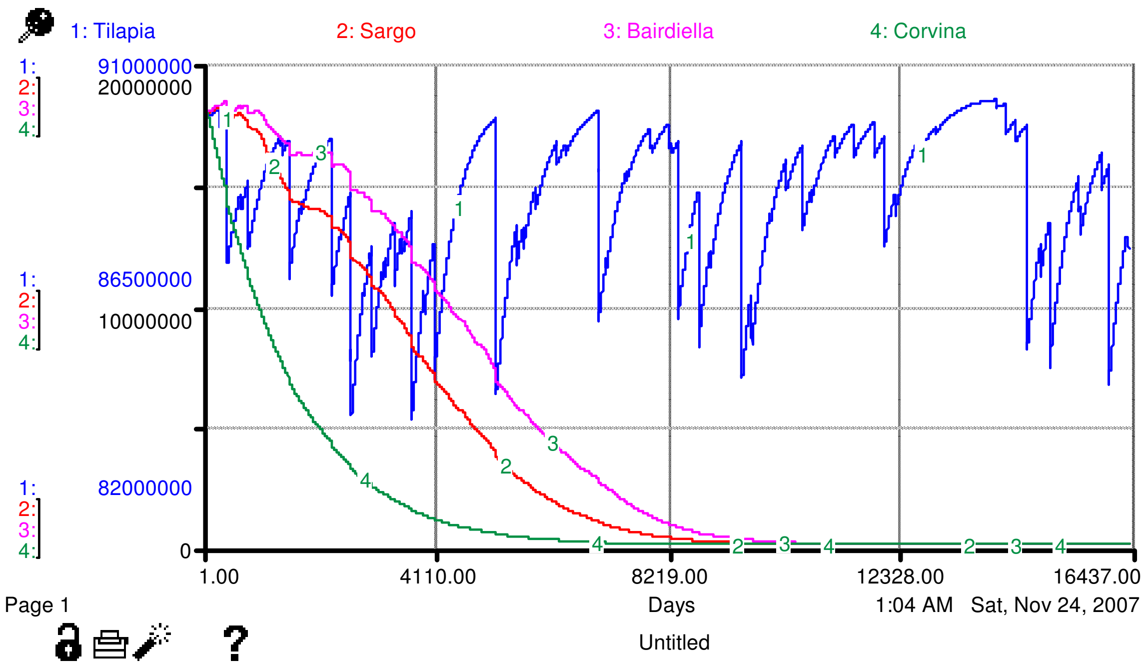


Fig. A.192 - Fish sensitivity analysis (strategy 1), ten percent increase: Salton Sea fish species' population comparison (1980 - 2024).

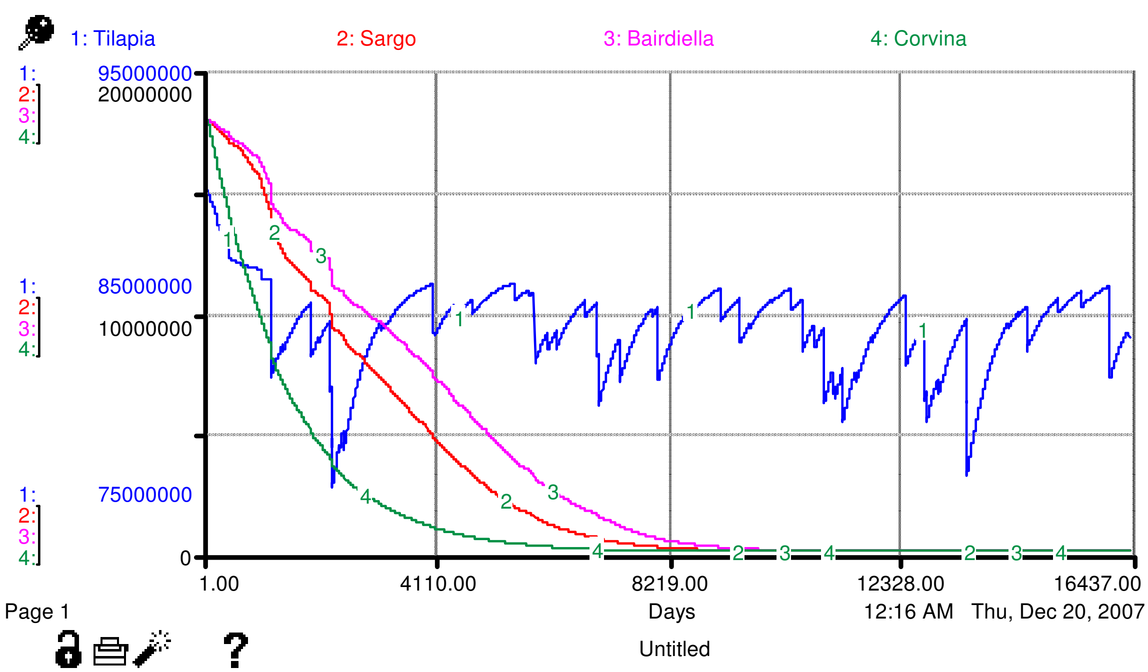


Fig. A.193 - Fish sensitivity analysis (strategy 1), ten percent decrease: Salton Sea fish species' population comparison (1980 - 2024).

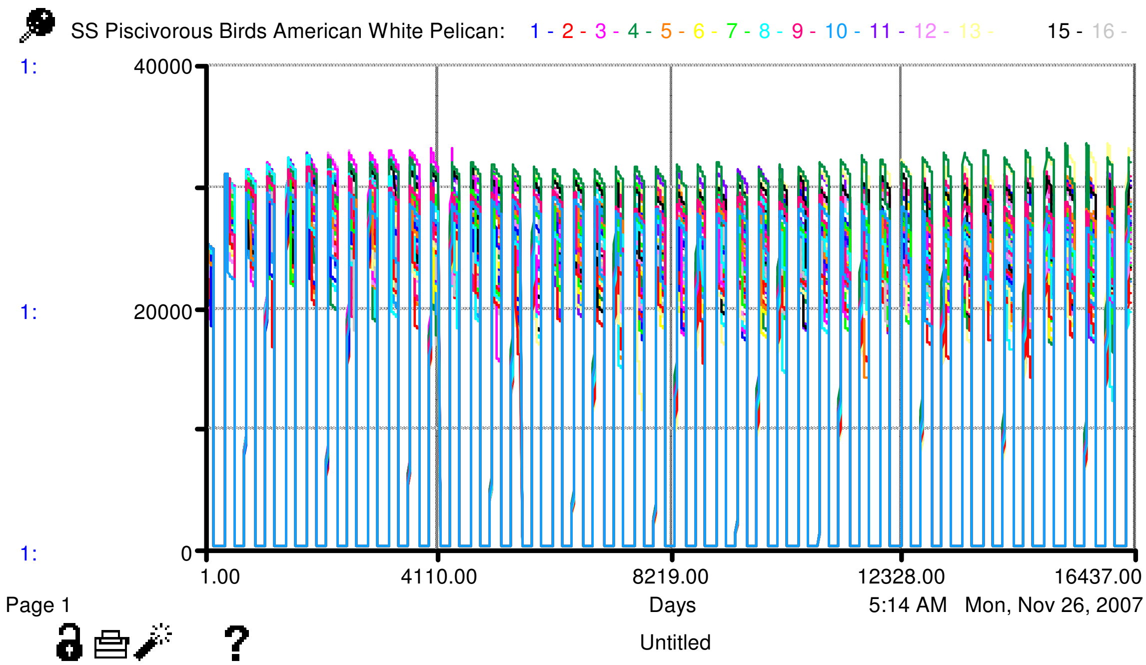


Fig. A.194 - Pelican sensitivity analysis (strategy 1), ten percent increase: Salton Sea AWP population (1980 - 2024).

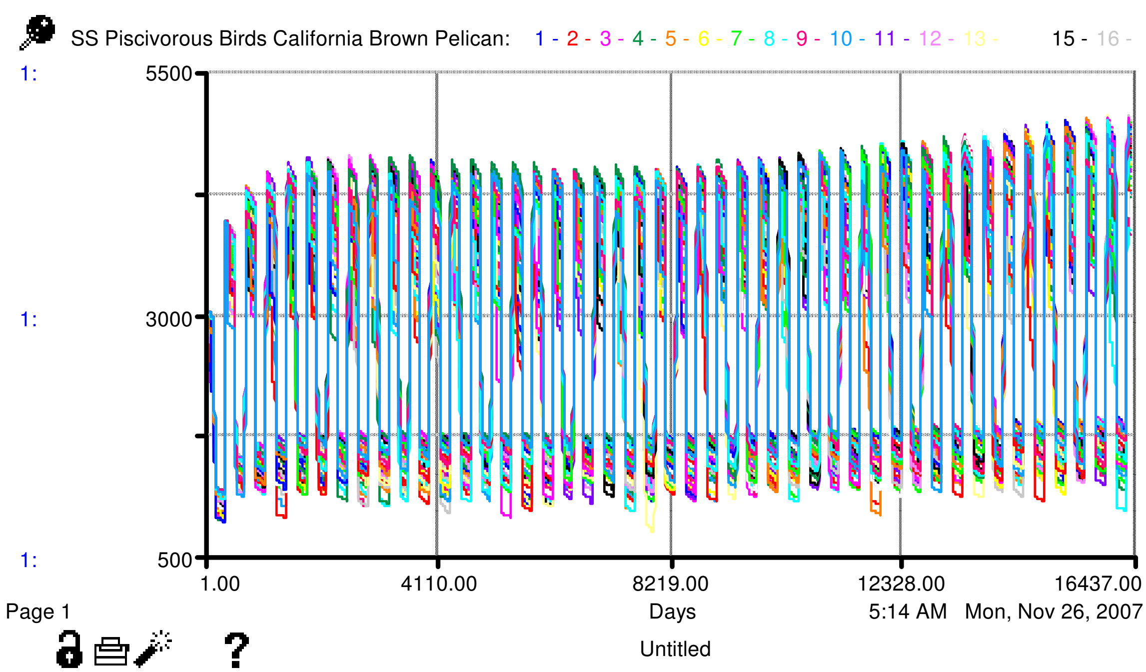


Fig. A.195 - Pelican sensitivity analysis (strategy 1), ten percent increase: Salton Sea CBP population (1980 - 2024).

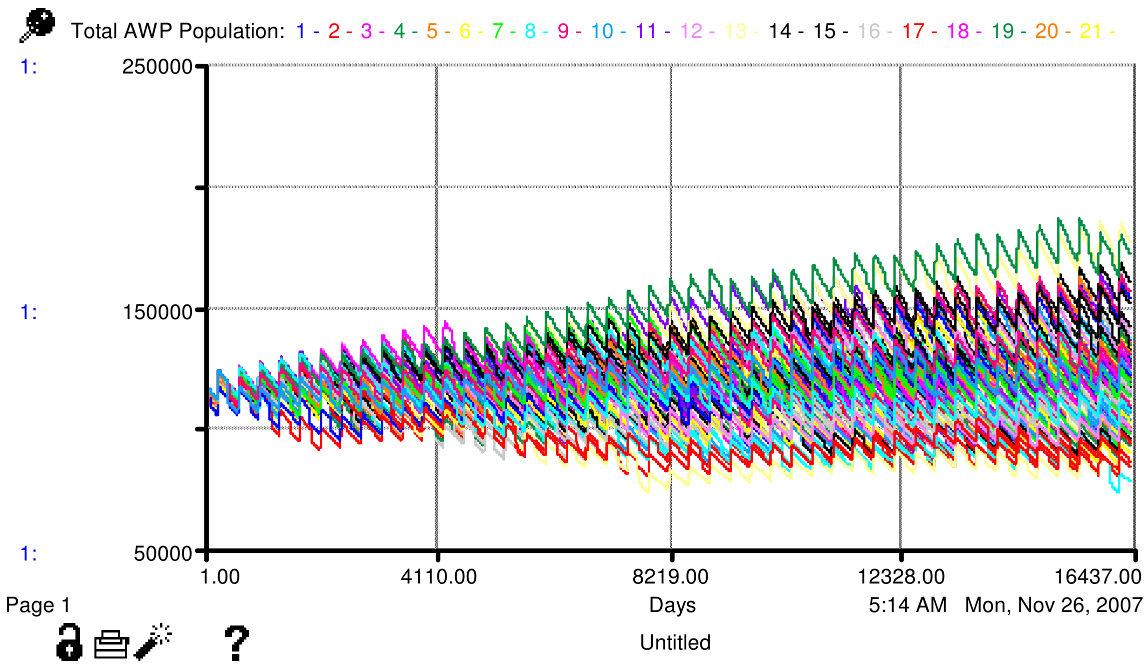


Fig. A.196 - Pelican sensitivity analysis (strategy 1), ten percent increase: continental AWP population (1980 - 2024).

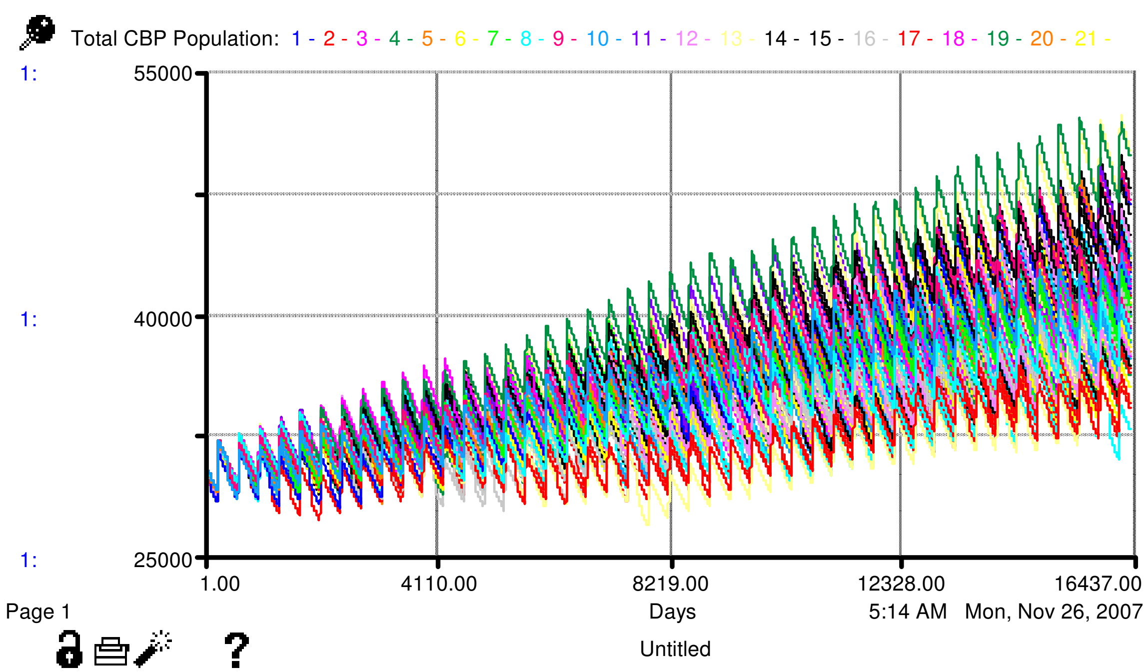


Fig. A.197 - Pelican sensitivity analysis (strategy 1), ten percent increase: continental CBP population (1980 - 2024).

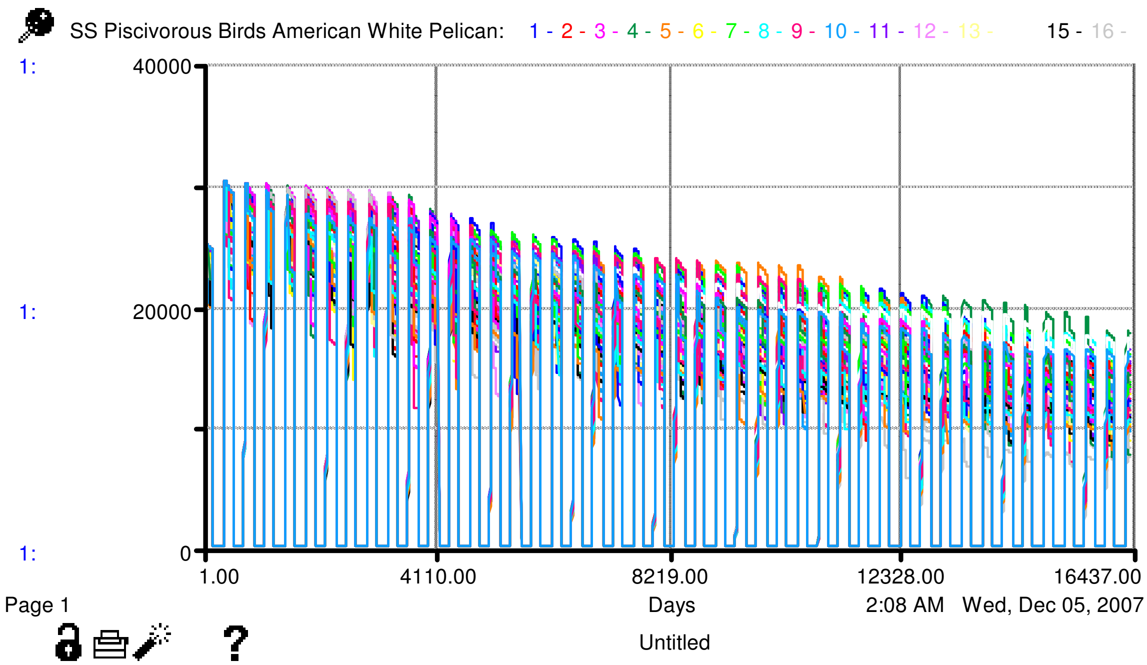


Fig. A.198 - Pelican sensitivity analysis (strategy 1), ten percent decrease: Salton Sea AWP population (1980 - 2024).

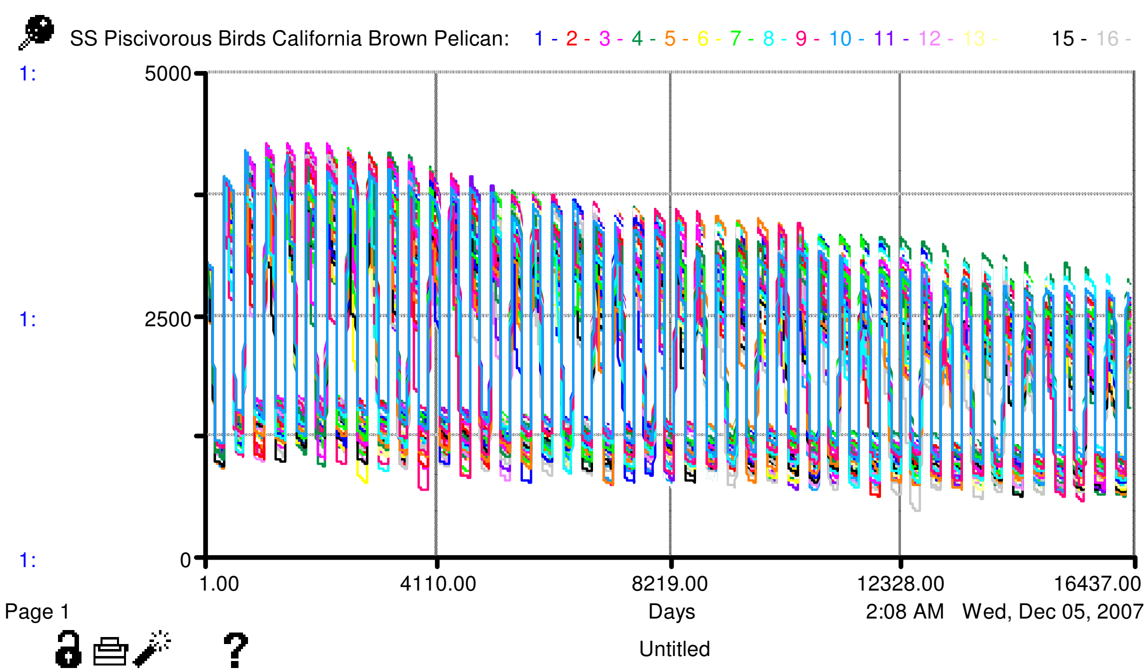


Fig. A.199 - Pelican sensitivity analysis (strategy 1), ten percent decrease: Salton Sea CBP population (1980 - 2024).

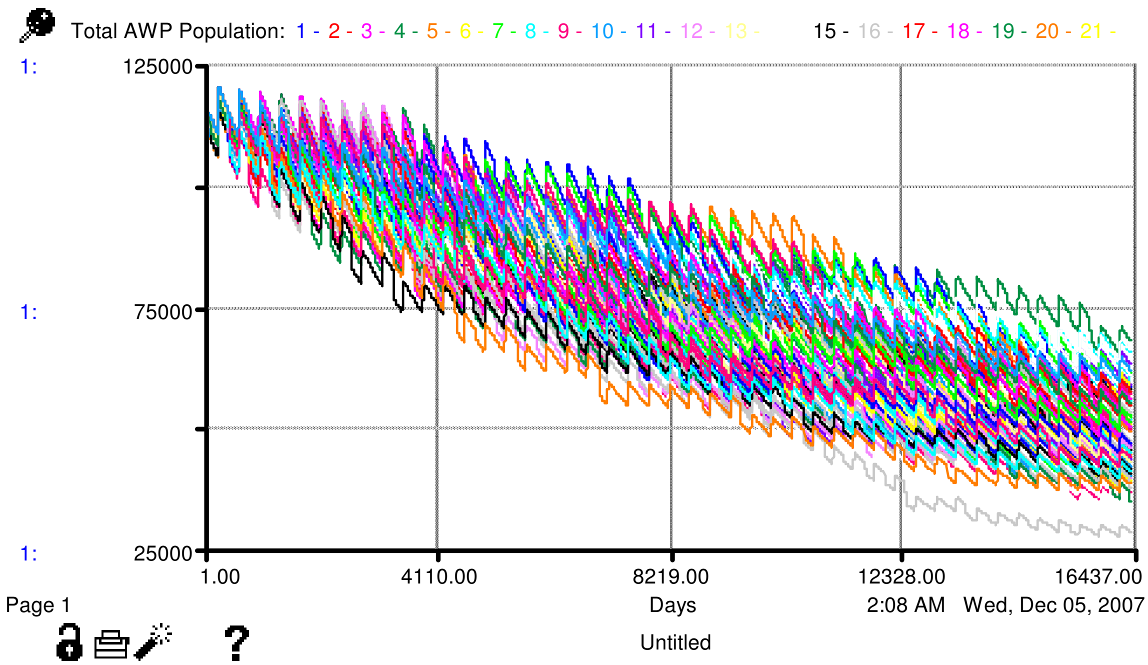


Fig. A.200 - Pelican sensitivity analysis (strategy 1), ten percent decrease: continental AWP population (1980 - 2024).

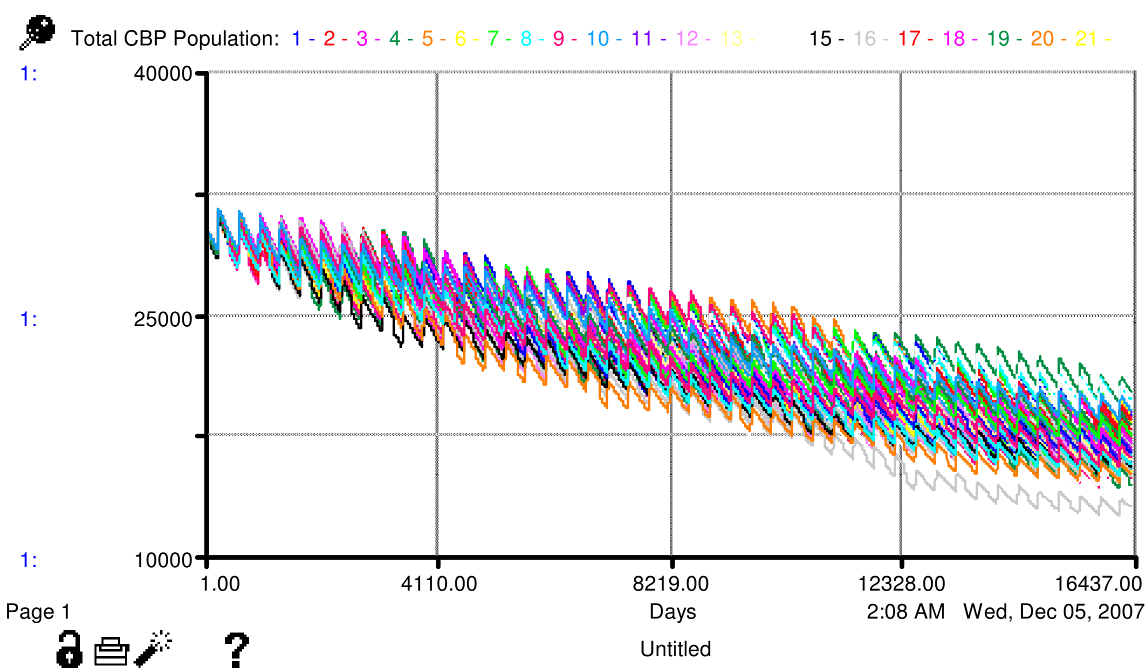


Fig. A.201 - Pelican sensitivity analysis (strategy 1), ten percent decrease: continental CBP population (1980 - 2024).

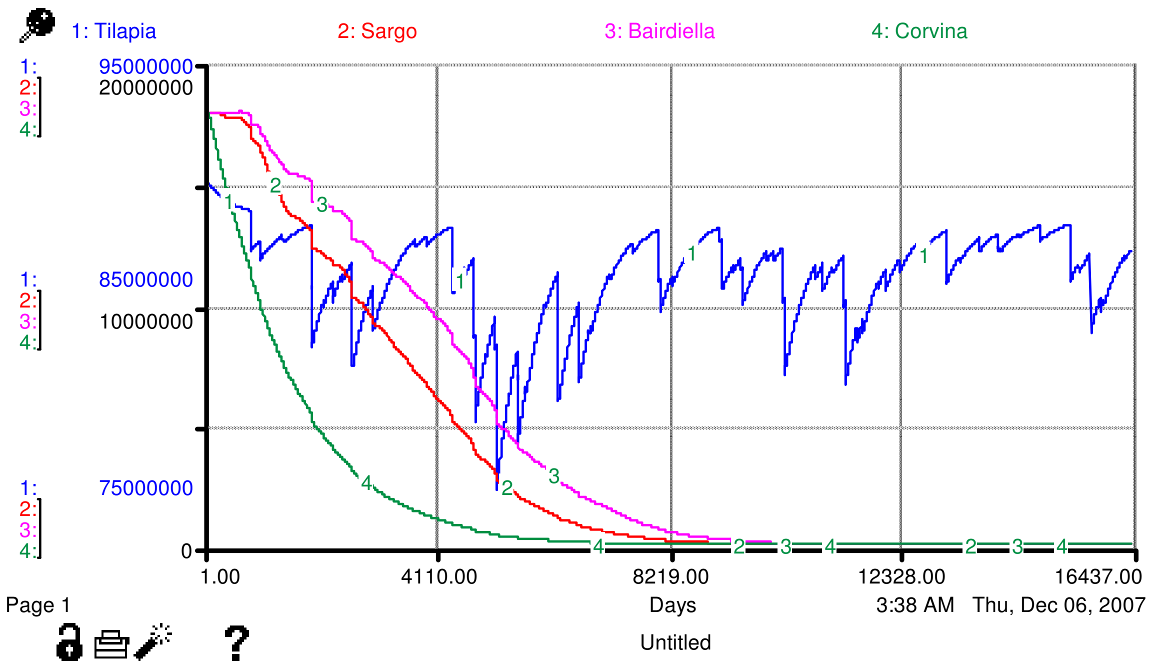


Fig. A.202 - New River wetlands scenario 2 (policy 1): Salton Sea fish species' population comparison (1980 - 2024).

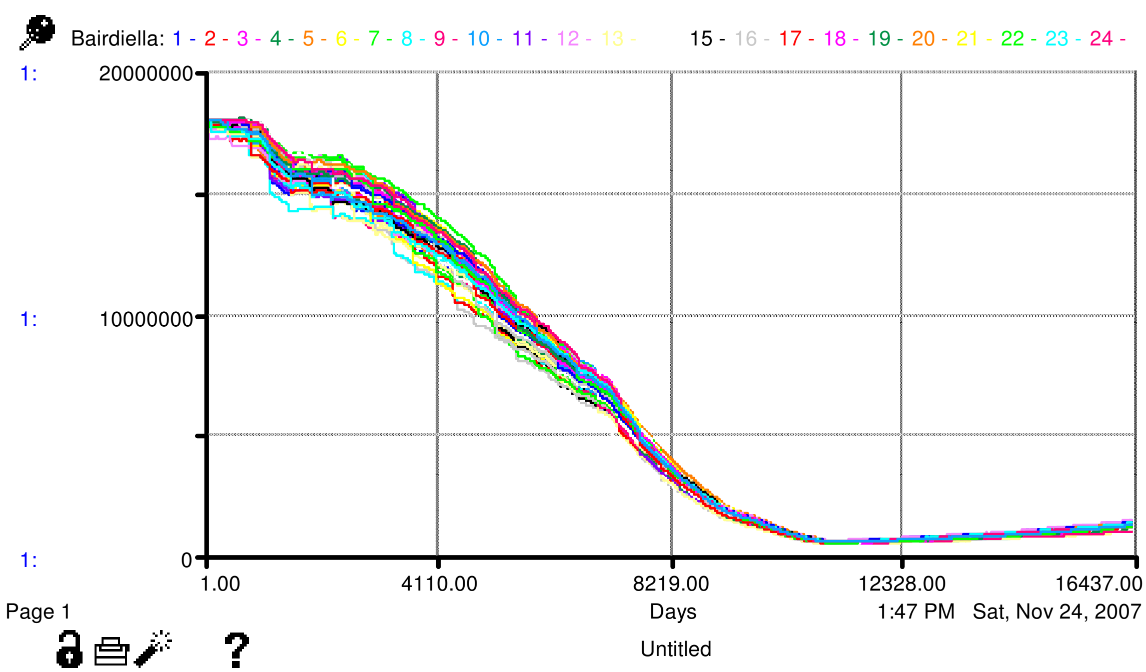


Fig. A.203 - Salton Sea impoundment design 1 (strategy 1): north impoundment Croaker population (1980 - 2024).

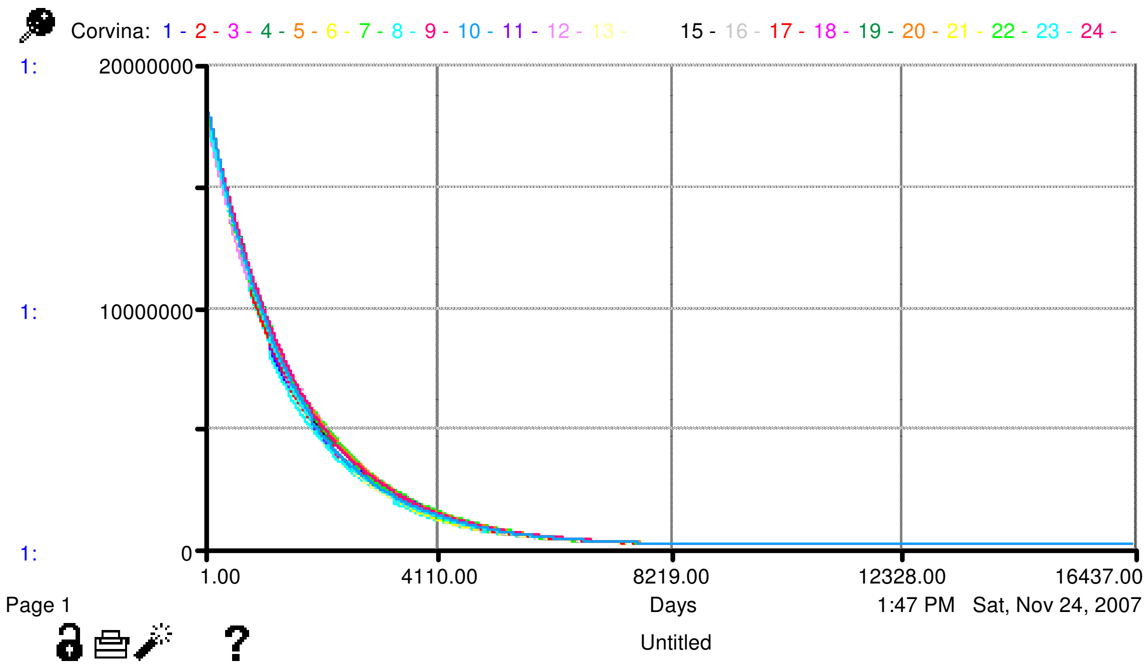


Fig. A.204 - Salton Sea impoundment design 1 (strategy 1): north impoundment Corvina population (1980 - 2024).

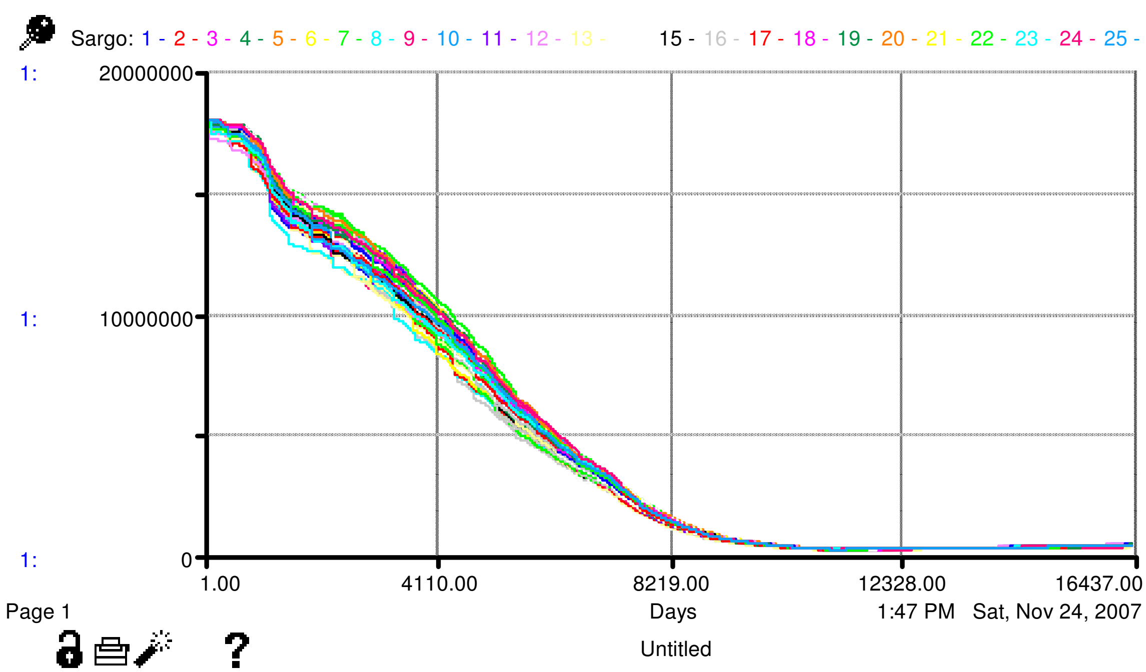


Fig. A.205 - Salton Sea impoundment design 1 (strategy 1): north impoundment Sargo population (1980 - 2024).

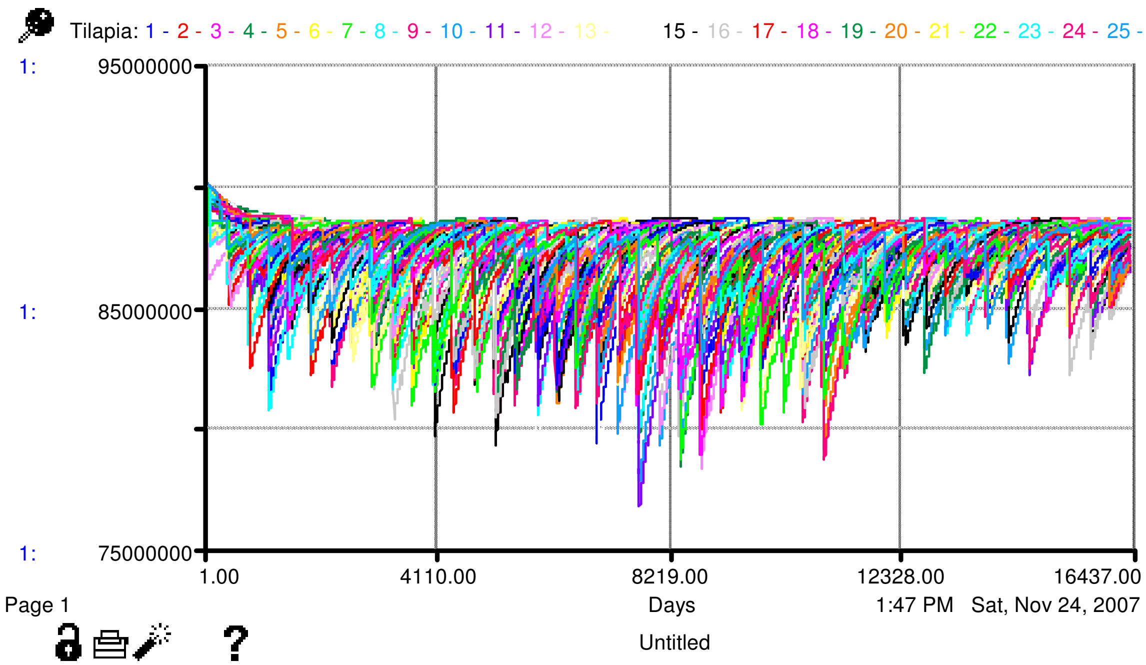


Fig. A.206 - Salton Sea impoundment design 1 (strategy 1): north impoundment Tilapia population (1980 - 2024).

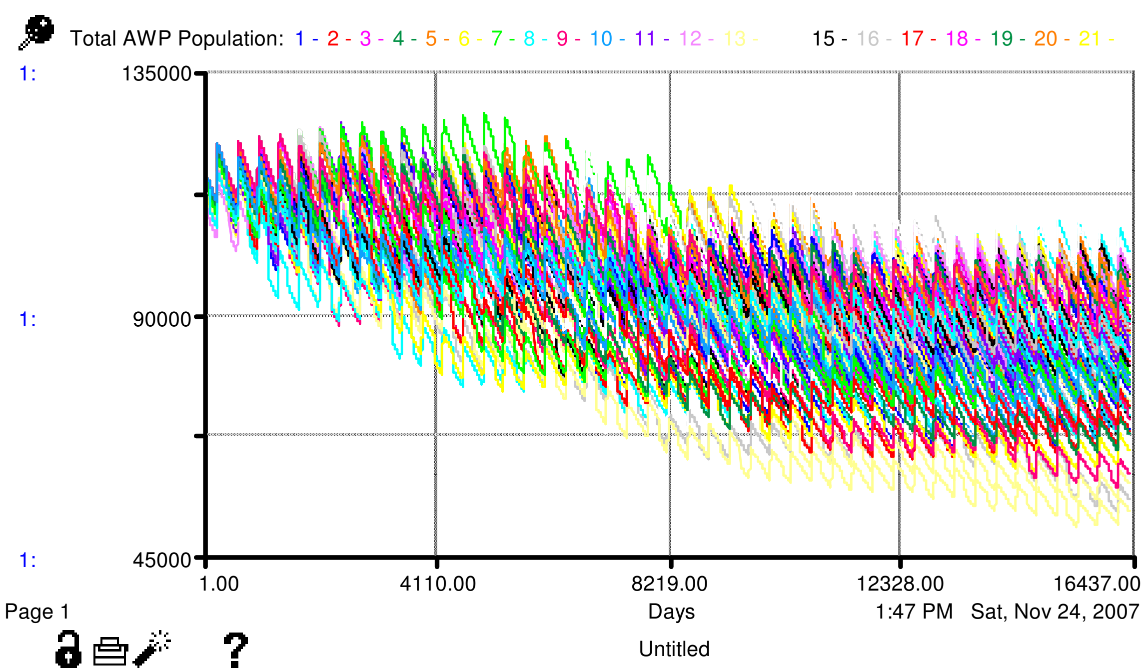


Fig. A.207 - Salton Sea impoundment design 1 (strategy 1): total continental American White Pelican (AWP) population (1980 - 2024).

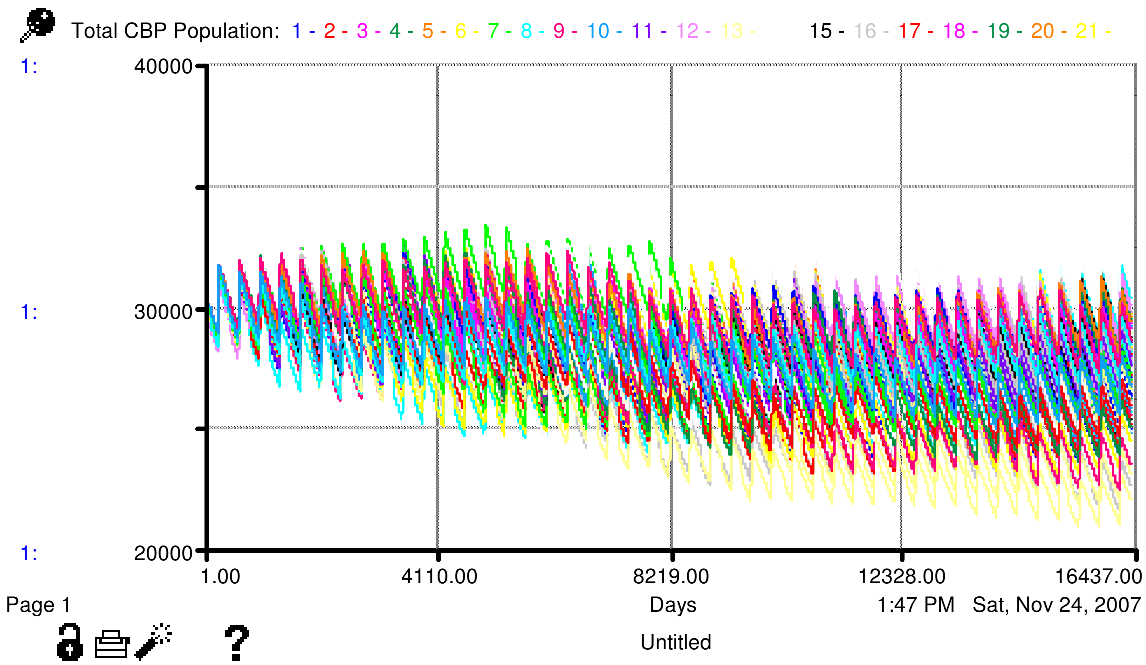


Fig. A.208 - Salton Sea impoundment design 1 (strategy 1): total continental California Brown Pelican (CBP) population (1980 - 2024).

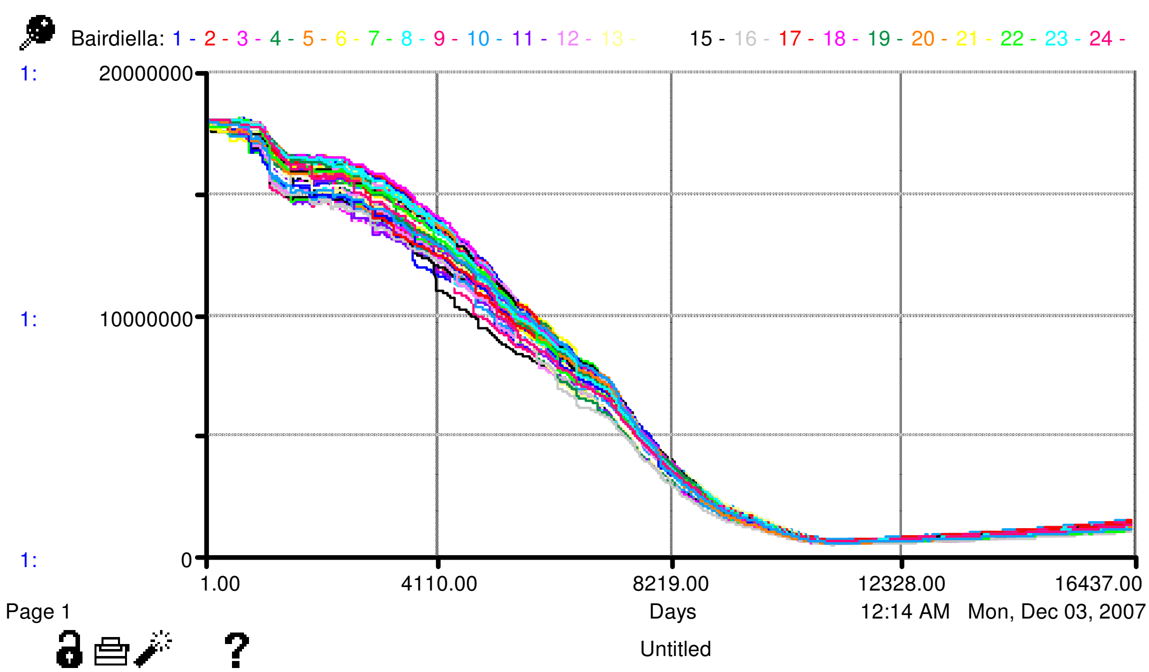


Fig. A.209 - Salton Sea impoundment design 2 (strategy 1): north impoundment Croaker population (1980 - 2024).

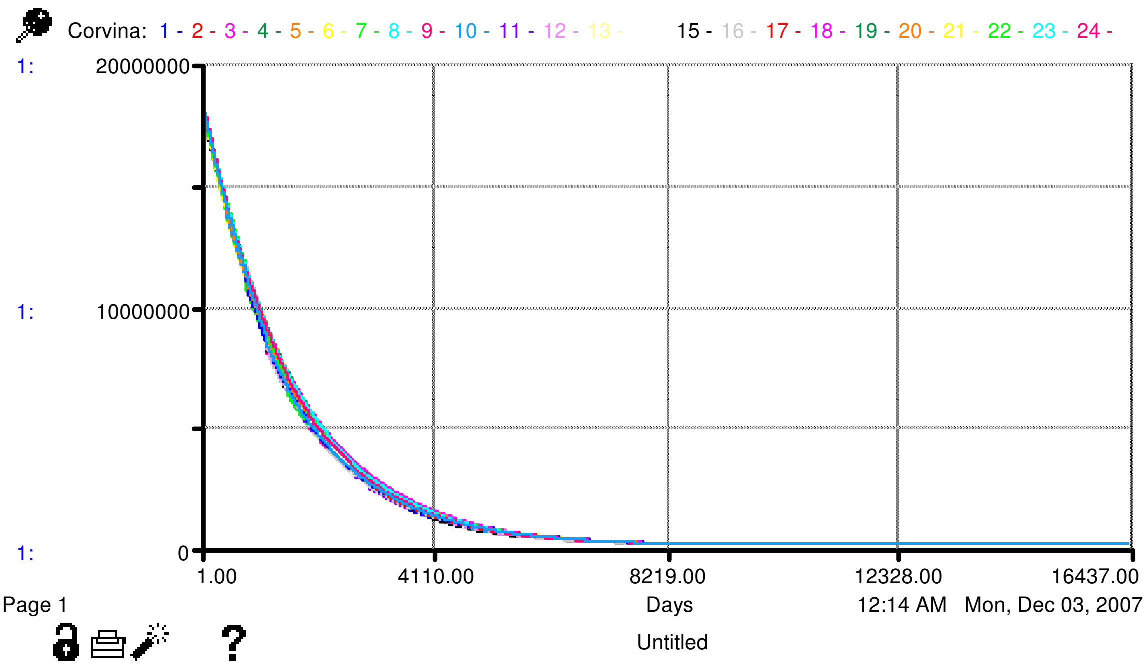


Fig. A.210 - Salton Sea impoundment design 2 (strategy 1): north impoundment Corvina population (1980 - 2024).

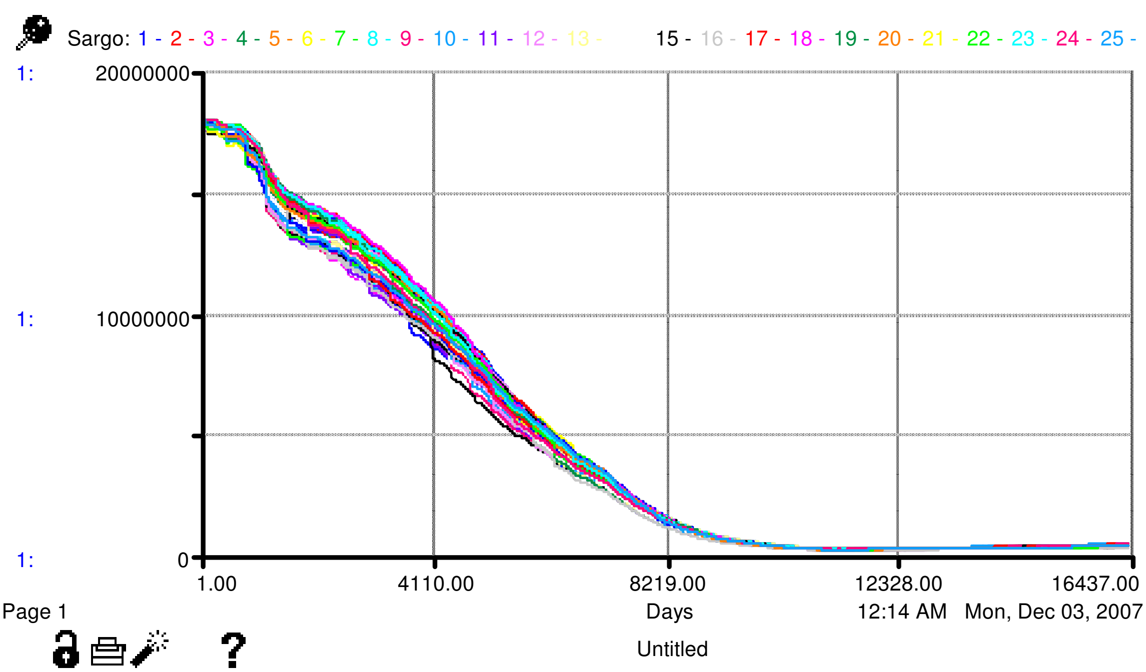


Fig. A.211 - Salton Sea impoundment design 2 (strategy 1): north impoundment Sargo population (1980 - 2024).

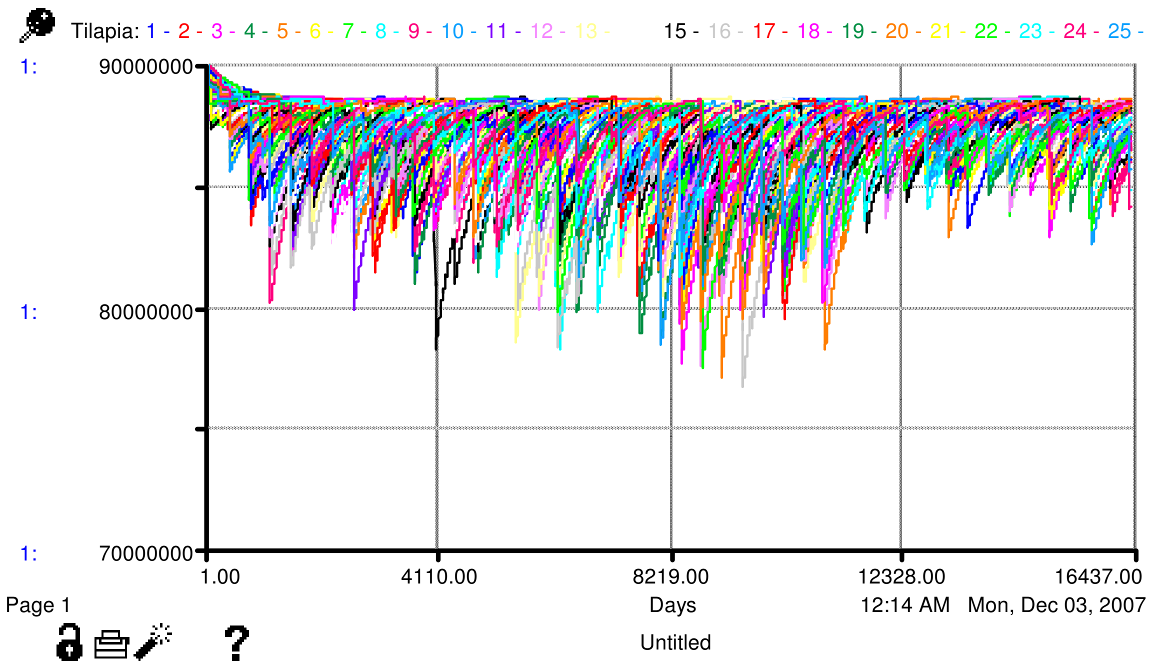


Fig. A.212 - Salton Sea impoundment design 2 (strategy 1): north impoundment Tilapia population (1980 - 2024).

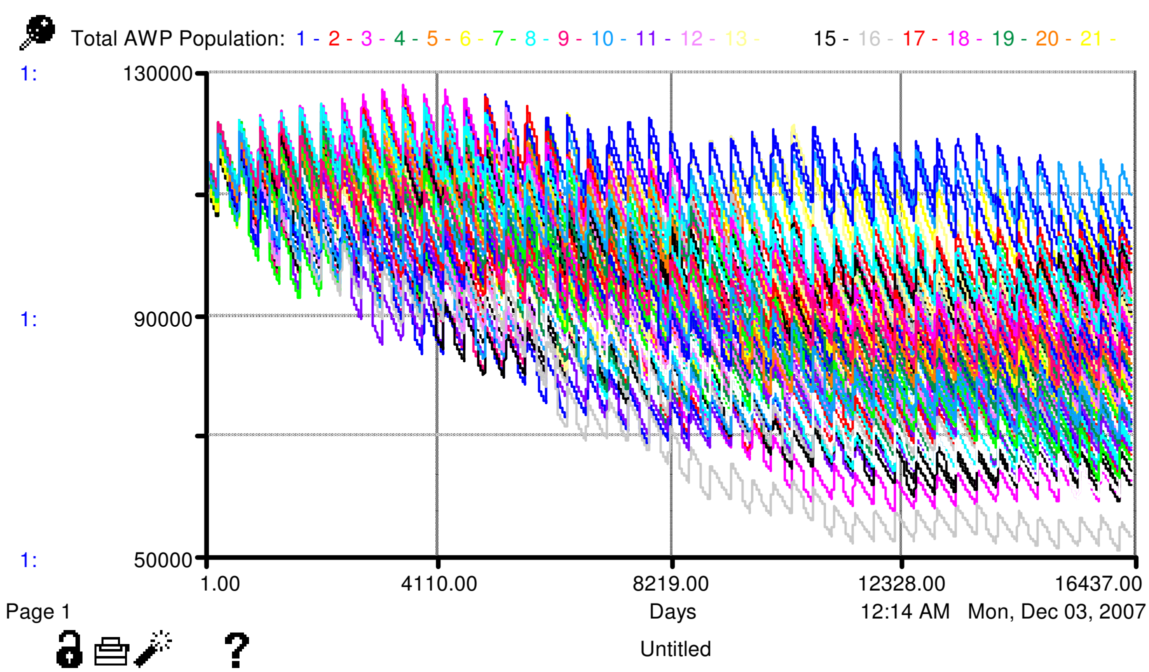


Fig. A.213 - Salton Sea impoundment design 2 (strategy 2): total continental American White Pelican (AWP) population (1980 - 2024).

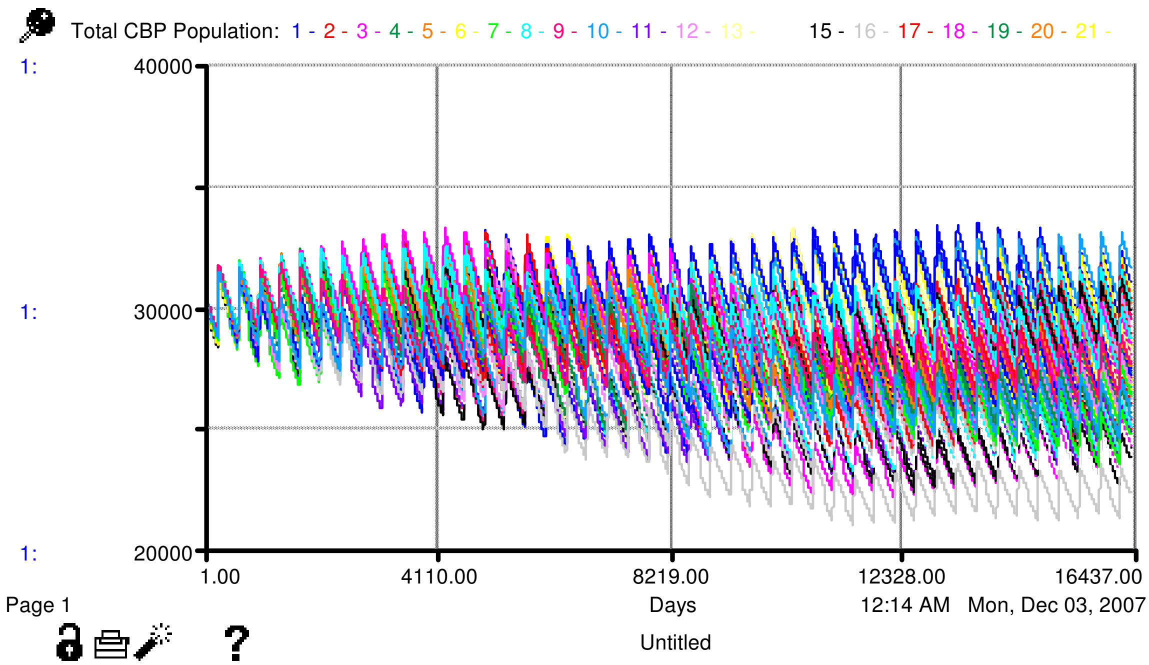


Fig. A.214 - Salton Sea impoundment design 2 (strategy 1): total continental California Brown Pelican (CBP) population (1980 - 2024).

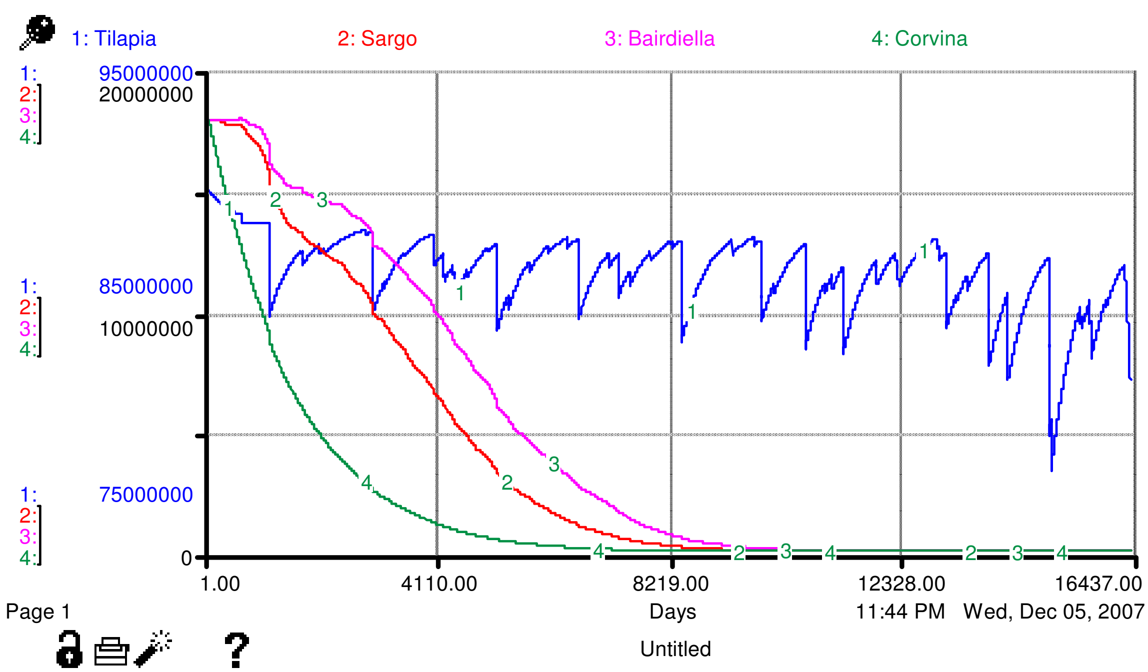


Fig. A.215 - Mexicali power plant scenario 2 (policy 4): Salton Sea fish species' population comparison (1980 - 2024).

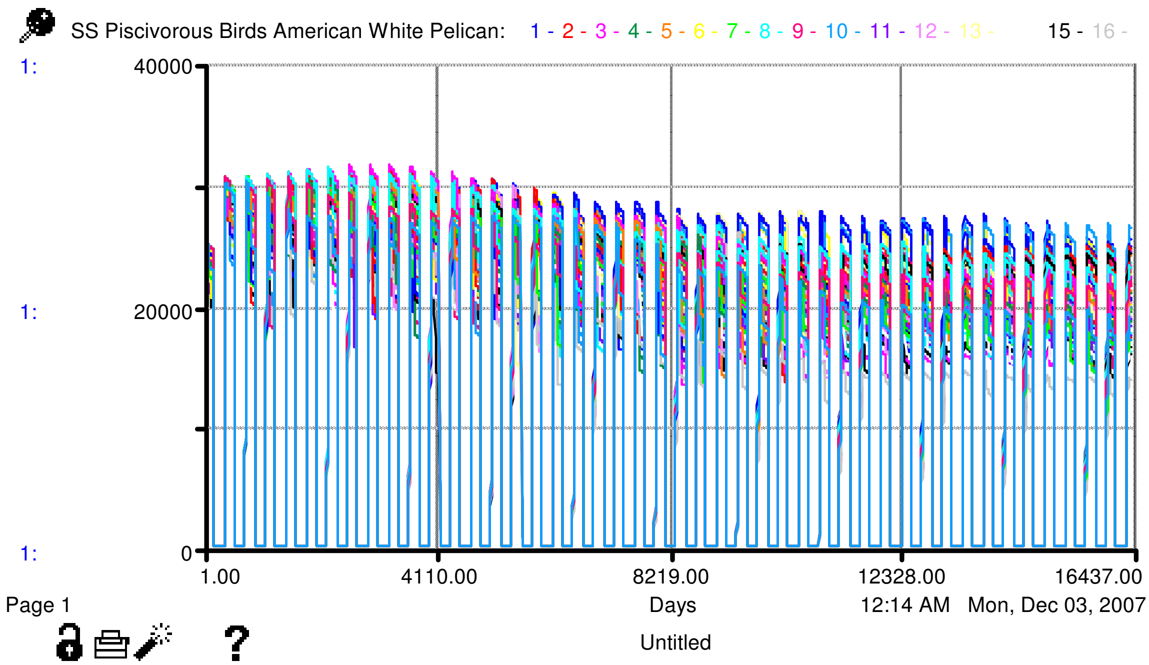


Fig. A.216 - Mexicali power plant scenario 2 (policy 4): AWP population (1980 - 2024).

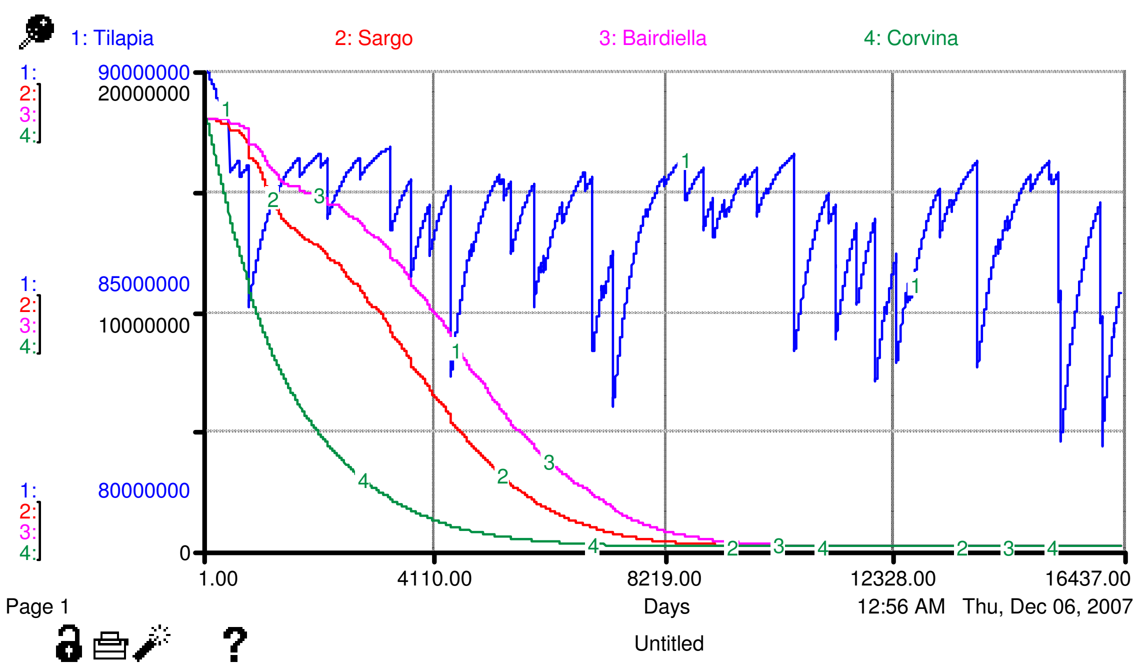


Fig. A.217 - AAC lining and agricultural fallowing scenario 2 (policy 3 & 5): Salton Sea fish species' population comparison (1980 - 2024).

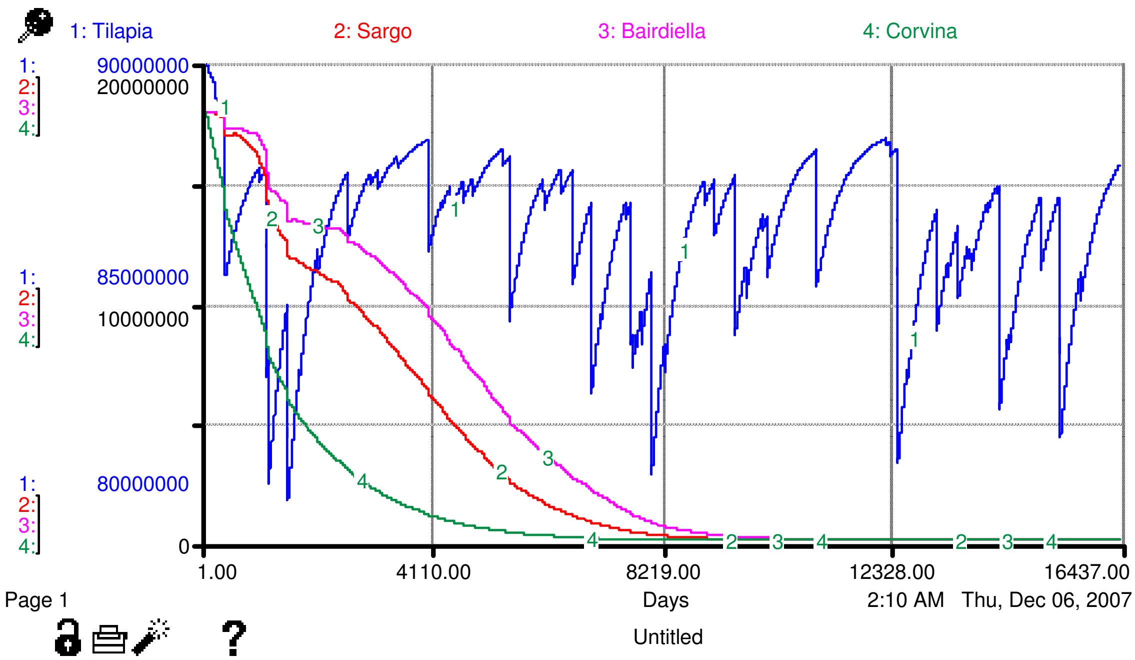


Fig. A.218 - AAC lining and agricultural fallowing scenario 3 (policy 3 & 5): Salton Sea fish species' population comparison (1980 - 2024).

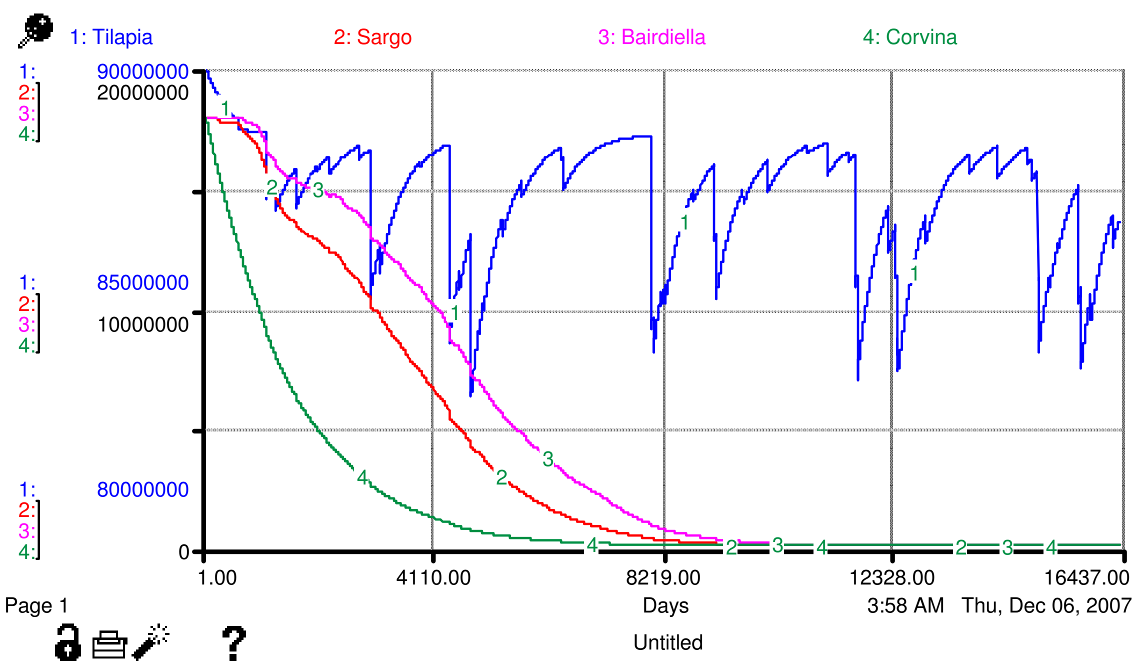


Fig. A.219 - AAC lining and agricultural fallowing scenario 4 (policy 3 & 5): Salton Sea fish species' population comparison (1980 - 2024).

APPENDIX B

Table B.1 - Scenario 2 Salton Sea TIN calculated elevation (ft), surface area (SA), and volume (Vol) correlations

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-220 to -227	0.10	234,830	235,110	9,350,905	4,144,717	5,206,102
-227 to -228	2.44	229,668	229,942	7,471,127	3,395,892	4,075,148
-228 to -229	2.74	225,262	225,529	7,247,652	3,306,515	3,941,060
-229 to -230	3.05	223,909	224,171	7,019,262	3,214,999	3,804,186
-230 to -231	3.35	222,912	223,170	6,799,360	3,126,813	3,672,470
-231 to -232	3.66	221,622	221,875	6,573,294	3,036,073	3,537,144
-232 to -233	3.96	220,618	220,866	6,355,645	2,948,637	3,406,930
-233 to -234	4.27	219,188	219,432	6,131,960	2,858,673	3,273,209
-234 to -235	4.57	217,883	218,122	5,916,840	2,772,013	3,144,750
-235 to -236	4.88	215,624	215,858	5,696,313	2,682,912	3,013,323
-236 to -237	5.18	213,395	213,623	5,485,142	2,597,201	2,887,863
-237 to -238	5.49	210,000	210,221	5,269,778	2,509,235	2,760,466
-238 to -239	5.79	207,213	207,429	5,064,436	2,424,747	2,639,612
-239 to -240	6.10	203,517	203,726	4,855,588	2,338,166	2,517,347
-240 to -241	6.40	200,847	201,050	4,656,584	2,255,092	2,401,417
-241 to -242	6.71	196,946	197,143	4,454,272	2,170,000	2,284,196
-242 to -243	7.01	194,013	194,204	4,261,850	2,088,403	2,173,372
-243 to -244	7.32	189,138	189,322	4,066,884	2,004,932	2,061,876
-244 to -245	7.62	184,760	184,937	3,882,482	1,925,002	1,957,404
-245 to -246	7.93	181,127	181,298	3,696,128	1,843,302	1,852,745
-246 to -247	8.23	177,327	177,492	3,519,461	1,765,105	1,754,278
-247 to -248	8.53	174,392	174,550	3,346,363	1,687,727	1,658,561
-248 to -249	8.84	170,920	171,072	3,171,065	1,608,580	1,562,410
-249 to -250	9.14	168,005	168,152	3,004,512	1,532,778	1,471,658

Table B.1 - (Continued)

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-250 to -251	9.45	164,565	164,707	2,835,383	1,455,296	1,380,010
-251 to -252	9.75	162,126	162,263	2,674,590	1,381,152	1,293,362
-252 to -253	10.06	158,772	158,904	2,511,391	1,305,428	1,205,888
-253 to -254	10.36	156,323	156,450	2,356,312	1,233,034	1,123,207
-254 to -255	10.67	152,700	152,822	2,199,134	1,159,226	1,039,840
-255 to -256	10.97	150,097	150,212	2,050,106	1,088,721	961,316
-256 to -257	11.28	146,352	146,462	1,899,318	1,016,801	882,446
-257 to -258	11.58	143,676	143,781	1,756,571	948,190	808,309
-258 to -259	11.89	139,939	140,039	1,612,339	878,358	733,909
-259 to -260	12.19	137,345	137,440	1,475,859	811,921	663,867
-260 to -261	12.50	133,259	133,348	1,338,195	744,512	593,615
-261 to -262	12.80	130,089	130,172	1,208,554	680,512	527,984
-262 to -263	13.11	125,383	125,460	1,078,563	615,759	462,750
-263 to -264	13.41	122,010	122,082	956,779	554,522	402,203
-264 to -265	13.72	116,601	116,667	835,449	492,811	342,582
-265 to -266	14.02	112,473	112,533	722,672	434,788	287,819
-266 to -267	14.33	106,535	106,590	611,264	376,721	234,482
-267 to -268	14.63	101,772	101,821	508,696	322,540	186,100
-268 to -269	14.94	93,750	93,794	409,011	268,858	140,078
-269 to -270	15.24	85,520	85,557	319,952	219,428	100,395
-270 to -271	15.55	73,162	73,192	237,651	171,350	66,185
-271 to -272	15.85	63,250	63,274	170,419	128,359	41,919
-272 to -273	16.15	50,790	50,808	115,719	90,562	24,975
-273 to -274	16.46	36,353	36,366	71,057	58,492	12,456
-274 to -275	16.76	27,629	27,637	39,666	34,546	5,010

Table B.1 - (Continued)

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-275 to -276	17.07	15,727	15,732	17,720	16,507	1,118
-276 to -277	17.37	10,199	10,202	4,997	4,753	144
-277 to -278	17.68	992	992	410	395	32
-278 to -279	17.98	67	67	1	0	0
-279 to -280	18.29	0	0	0	0	0

Table B.2 - Scenario 3 Salton Sea TIN calculated elevation (ft), surface area (SA), and volume (Vol) correlations

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-220 to -227	0.10	234,830	235,109	9,350,863	6,338,009	0
-227 to -228	2.44	229,660	229,932	7,471,084	4,458,230	0
-228 to -229	2.74	225,264	225,529	7,247,612	4,234,757	0
-229 to -230	3.05	223,913	224,173	7,019,216	4,006,361	0
-230 to -231	3.35	222,924	223,180	6,799,307	3,786,452	0
-231 to -232	3.66	221,626	221,878	6,573,237	3,560,382	0
-232 to -233	3.96	220,621	220,868	6,355,583	3,342,728	0
-233 to -234	4.27	219,193	219,435	6,131,895	3,119,040	0
-234 to -235	4.57	217,886	218,124	5,916,770	2,903,656	3,012,855
-235 to -236	4.88	215,594	215,826	5,696,272	2,789,967	2,906,045
-236 to -237	5.18	213,326	213,553	5,485,151	2,682,210	2,802,682
-237 to -238	5.49	209,953	210,174	5,269,850	2,573,716	2,695,875
-238 to -239	5.79	207,090	207,305	5,064,603	2,471,831	2,592,516
-239 to -240	6.10	203,478	203,687	4,855,824	2,369,854	2,485,715
-240 to -241	6.40	200,754	200,957	4,656,879	2,274,261	2,382,365
-241 to -242	6.71	196,919	197,115	4,454,604	2,178,767	2,275,589
-242 to -243	7.01	194,021	194,212	4,262,192	2,089,559	2,172,388
-243 to -244	7.32	189,184	189,368	4,067,211	2,000,817	2,066,210
-244 to -245	7.62	184,837	185,014	3,882,740	1,918,474	1,964,136
-245 to -246	7.93	181,106	181,276	3,696,296	1,836,321	1,859,988
-246 to -247	8.23	177,314	177,478	3,519,616	1,758,288	1,761,407
-247 to -248	8.53	174,386	174,544	3,346,523	1,681,178	1,665,439
-248 to -249	8.84	170,919	171,071	3,171,227	1,602,330	1,568,996
-249 to -250	9.14	168,004	168,151	3,004,675	1,526,826	1,477,949

Table B.2 - (Continued)

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-250 to -251	9.45	164,560	164,702	2,835,551	1,449,658	1,385,990
-251 to -252	9.75	162,124	162,261	2,674,763	1,375,820	1,299,040
-252 to -253	10.06	158,765	158,897	2,511,565	1,300,411	1,211,250
-253 to -254	10.36	156,321	156,447	2,356,490	1,228,322	1,128,265
-254 to -255	10.67	152,700	152,822	2,199,315	1,154,826	1,044,586
-255 to -256	10.97	150,099	150,215	2,050,285	1,084,621	965,762
-256 to -257	11.28	146,353	146,463	1,899,494	1,013,008	886,583
-257 to -258	11.58	143,676	143,781	1,756,747	944,693	812,151
-258 to -259	11.89	139,939	140,038	1,612,514	875,161	737,450
-259 to -260	12.19	137,345	137,439	1,476,035	809,013	667,119
-260 to -261	12.50	133,260	133,348	1,338,374	741,895	596,576
-261 to -262	12.80	130,084	130,167	1,208,735	678,170	530,662
-262 to -263	13.11	125,384	125,462	1,078,744	613,700	465,141
-263 to -264	13.41	122,008	122,080	956,960	552,731	404,325
-264 to -265	13.72	116,602	116,668	835,628	491,288	344,437
-265 to -266	14.02	112,479	112,539	722,849	433,519	289,424
-266 to -267	14.33	106,532	106,587	611,445	375,709	235,831
-267 to -268	14.63	101,773	101,822	508,877	321,765	187,208
-268 to -269	14.94	93,887	93,931	409,173	268,319	140,949
-269 to -270	15.24	85,551	85,588	320,060	219,098	101,058
-270 to -271	15.55	73,168	73,198	237,752	171,216	66,613
-271 to -272	15.85	63,245	63,269	170,507	128,395	42,186
-272 to -273	16.15	50,946	50,964	115,675	90,720	25,019
-273 to -274	16.46	36,361	36,373	71,065	58,607	12,480

Table B.2 - (Continued)

Elevation	Depth (m)*	SA (acres)	3D SA (acres)	Volume (af)**	North Sea (af)	South Sea (af)
-274 to -275	16.76	27,629	27,637	39,671	34,656	5,025
-275 to -276	17.07	15,727	15,732	17,725	16,602	1,118
-276 to -277	17.37	10,200	10,202	4,997	4,853	144
-277 to -278	17.68	1,009	1,009	413	378	32
-278 to -279	17.98	67	67	1	0	0
-279 to -280	18.29	0	0	0	0	0

Table B.3 - Scenario 2 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations for the Salton Sea and north and south seas

Elevation	Depth (m)*	SA (acres)*	North Sea SA (acres)	South Sea SA (acres)
-220 to -227	0.10	234,830	93,543	141,287
-227 to -228	2.44	229,668	91,696	137,952
-228 to -229	2.74	225,262	90,213	135,049
-229 to -230	3.05	223,909	89,760	134,149
-230 to -231	3.35	222,912	89,428	133,484
-231 to -232	3.66	221,622	88,999	132,623
-232 to -233	3.96	220,618	88,660	131,958
-233 to -234	4.27	219,188	88,227	130,961
-234 to -235	4.57	217,883	87,855	130,027
-235 to -236	4.88	215,624	87,328	128,296
-236 to -237	5.18	213,395	86,827	126,568
-237 to -238	5.49	210,000	86,129	123,871
-238 to -239	5.79	207,213	85,537	121,676
-239 to -240	6.10	203,517	84,715	118,801
-240 to -241	6.40	200,847	84,082	116,765
-241 to -242	6.71	196,946	83,234	113,713
-242 to -243	7.01	194,013	82,565	111,449
-243 to -244	7.32	189,138	81,562	107,578
-244 to -245	7.62	184,760	80,711	104,048
-245 to -246	7.93	181,127	79,805	101,330
-246 to -247	8.23	177,327	78,968	98,357
-247 to -248	8.53	174,392	78,254	96,133
-248 to -249	8.84	170,920	77,460	93,457
-249 to -250	9.14	168,005	76,664	91,340

Table B.3 - (Continued)

Elevation	Depth (m)*	SA (acres)*	North Sea (acres)	South Sea (acres)
-250 to -251	9.45	164,565	75,673	88,892
-251 to -252	9.75	162,126	74,967	87,156
-252 to -253	10.06	158,772	73,950	84,815
-253 to -254	10.36	156,323	73,131	83,189
-254 to -255	10.67	152,700	72,005	80,695
-255 to -256	10.97	150,097	71,256	78,843
-256 to -257	11.28	146,352	70,140	76,213
-257 to -258	11.58	143,676	69,262	74,413
-258 to -259	11.89	139,939	68,009	71,930
-259 to -260	12.19	137,345	66,989	70,356
-260 to -261	12.50	133,259	65,589	67,665
-261 to -262	12.80	130,089	64,445	65,633
-262 to -263	13.11	125,383	62,830	62,552
-263 to -264	13.41	122,010	61,582	60,426
-264 to -265	13.72	116,601	59,704	56,909
-265 to -266	14.02	112,473	58,176	54,305
-266 to -267	14.33	106,535	55,965	50,563
-267 to -268	14.63	101,772	54,115	47,647
-268 to -269	14.94	93,750	51,353	42,558
-269 to -270	15.24	85,520	48,582	36,937
-270 to -271	15.55	73,162	45,251	27,911
-271 to -272	15.85	63,250	41,943	21,351
-272 to -273	16.15	50,790	35,894	14,826
-273 to -274	16.46	36,353	27,020	9,396

Table B.3 - (Continued)

Elevation	Depth (m)*	SA (acres)*	North Sea (acres)	South Sea (acres)
-274 to -275	16.76	27,629	21,626	5,900
-275 to -276	17.07	15,727	13,994	1,620
-276 to -277	17.37	10,199	9,850	432
-277 to -278	17.68	992	1,087	49
-278 to -279	17.98	67	4	17
-279 to -280	18.29	0	0	0

Table B.4 - Scenario 3 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations for the Salton Sea and north and south seas

Elevation	Depth (m)*	SA (acres)*	North Sea SA (acres)	South Sea SA (acres)
-220 to -227	0.10	234,830	129,811	0
-227 to -228	2.44	229,660	124,641	0
-228 to -229	2.74	225,264	120,245	0
-229 to -230	3.05	223,913	118,894	0
-230 to -231	3.35	222,924	117,905	0
-231 to -232	3.66	221,626	116,608	0
-232 to -233	3.96	220,621	115,603	0
-233 to -234	4.27	219,193	114,174	0
-234 to -235	4.57	217,886	112,868	105,018
-235 to -236	4.88	215,594	110,576	105,017
-236 to -237	5.18	213,326	108,310	105,016
-237 to -238	5.49	209,953	104,939	105,014
-238 to -239	5.79	207,090	102,075	105,011
-239 to -240	6.10	203,478	98,472	105,007
-240 to -241	6.40	200,754	95,751	105,001
-241 to -242	6.71	196,919	91,967	104,951
-242 to -243	7.01	194,021	89,270	104,743
-243 to -244	7.32	189,184	85,072	104,037
-244 to -245	7.62	184,837	81,641	103,064
-245 to -246	7.93	181,106	79,719	101,287
-246 to -247	8.23	177,314	78,705	98,596
-247 to -248	8.53	174,386	77,969	96,407
-248 to -249	8.84	170,919	77,161	93,753
-249 to -250	9.14	168,004	76,359	91,644

Table B.4 - (Continued)

Elevation	Depth (m)*	SA (acres)*	North Sea SA (acres)	South Sea SA (acres)
-250 to -251	9.45	164,560	75,362	89,199
-251 to -252	9.75	162,124	74,656	87,467
-252 to -253	10.06	158,765	73,640	85,125
-253 to -254	10.36	156,321	72,824	83,497
-254 to -255	10.67	152,700	71,700	81,001
-255 to -256	10.97	150,099	70,952	79,147
-256 to -257	11.28	146,353	69,839	76,515
-257 to -258	11.58	143,676	68,965	74,711
-258 to -259	11.89	139,939	67,715	72,224
-259 to -260	12.19	137,345	66,697	70,646
-260 to -261	12.50	133,260	65,308	67,950
-261 to -262	12.80	130,084	64,165	65,918
-262 to -263	13.11	125,384	62,555	62,829
-263 to -264	13.41	122,008	61,312	60,699
-264 to -265	13.72	116,602	59,443	57,165
-265 to -266	14.02	112,479	57,923	54,558
-266 to -267	14.33	106,532	55,719	50,812
-267 to -268	14.63	101,773	53,879	47,891
-268 to -269	14.94	93,887	51,129	42,747
-269 to -270	15.24	85,551	48,380	37,180
-270 to -271	15.55	73,168	45,090	28,093
-271 to -272	15.85	63,245	41,751	21,473
-272 to -273	16.15	50,946	35,839	15,114

Table B.4 - (Continued)

Elevation	Depth (m)*	SA (acres)*	North Sea SA (acres)	South Sea SA (acres)
-273 to -274	16.46	36,361	26,974	9,411
-274 to -275	16.76	27,629	21,729	5,898
-275 to -276	17.07	15,727	14,107	1,620
-276 to -277	17.37	10,200	9,768	432
-277 to -278	17.68	1,009	942	49
-278 to -279	17.98	67	50	17
-279 to -280	18.29	0	0	0

Table B.5 - Scenario 2 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations versus United States Bureau of Reclamation (USBR) report calculations

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-227	9,350,819	9,318,560	32,259	0.003	0.003
-228	7,471,040	7,391,803	79,237	0.011	0.009
-229	7,247,576	7,160,886	86,690	0.012	0.009
-230	7,019,185	6,932,056	87,129	0.013	0.009
-231	6,799,283	6,705,285	93,998	0.014	0.010
-232	6,573,217	6,480,546	92,671	0.014	0.010
-233	6,355,567	6,257,802	97,765	0.016	0.010
-234	6,131,882	6,037,084	94,798	0.016	0.010
-235	5,916,763	5,818,624	98,139	0.017	0.011
-236	5,696,236	5,602,705	93,531	0.017	0.010
-237	5,485,065	5,389,422	95,643	0.018	0.010
-238	5,269,700	5,179,311	90,389	0.017	0.010
-239	5,064,359	4,972,368	91,991	0.019	0.010
-240	4,855,513	4,768,461	87,052	0.018	0.009
-241	4,656,509	4,567,742	88,767	0.019	0.010
-242	4,454,197	4,370,492	83,705	0.019	0.009
-243	4,261,775	4,176,760	85,015	0.020	0.009
-244	4,066,808	3,986,863	79,945	0.020	0.009
-245	3,882,406	3,801,204	81,202	0.021	0.009
-246	3,696,047	3,619,455	76,592	0.021	0.008
-247	3,519,383	3,441,478	77,905	0.023	0.008
-248	3,346,288	3,267,126	79,162	0.024	0.008
-249	3,170,990	3,096,217	74,773	0.024	0.008
-250	3,004,437	2,928,427	76,010	0.026	0.008

Table B.5 - (Continued)

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-251	2,835,306	2,763,584	71,722	0.026	0.008
-252	2,674,515	2,601,679	72,836	0.028	0.008
-253	2,511,316	2,442,615	68,701	0.028	0.007
-254	2,356,241	2,286,483	69,758	0.031	0.007
-255	2,199,066	2,133,403	65,663	0.031	0.007
-256	2,050,037	1,983,488	66,549	0.034	0.007
-257	1,899,246	1,836,777	62,469	0.034	0.007
-258	1,756,499	1,693,324	63,175	0.037	0.007
-259	1,612,268	1,553,100	59,168	0.038	0.006
-260	1,475,788	1,416,184	59,604	0.042	0.006
-261	1,338,128	1,282,788	55,340	0.043	0.006
-262	1,208,496	1,153,081	55,415	0.048	0.006
-263	1,078,509	1,027,263	51,246	0.050	0.005
-264	956,725	905,703	51,022	0.056	0.005
-265	835,392	788,829	46,563	0.059	0.005
-266	722,607	676,759	45,848	0.068	0.005
-267	611,202	569,758	41,444	0.073	0.004
-268	508,640	468,355	40,285	0.086	0.004
-269	408,936	373,465	35,471	0.095	0.004
-270	319,823	287,057	32,766	0.114	0.004
-271	237,535	212,239	25,296	0.119	0.003
-272	170,277	149,183	21,094	0.141	0.002
-273	115,536	97,925	17,611	0.180	0.002

Table B.5 - (Continued)

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-274	70,948	57,804	13,144	0.227	0.001
-275	39,556	30,013	9,543	0.318	0.001
-276	17,624	12,382	5,242	0.423	0.001
-277	4,897	2,828	2,069	0.732	0.000
-278	427	52	375	7.216	0.000
-279	0	0	0	0.000	0.000
-280	0	0	0	0.000	0.000

Table B.6 - Scenario 2 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations versus United States Bureau of Reclamation (USBR) report calculations

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-227	234,830	250,082	-15,252	-0.060988723	-0.060988723
-228	229,647	231,973	-2,326	-0.010025723	-0.009299738
-229	225,262	229,868	-4,606	-0.020037011	-0.018417429
-230	223,909	227,798	-3,889	-0.017072325	-0.015551065
-231	222,912	225,750	-2,838	-0.012572012	-0.011348804
-232	221,622	223,734	-2,112	-0.009437571	-0.008443253
-233	220,618	221,752	-1,134	-0.005115093	-0.00453564
-234	219,188	219,640	-452	-0.00205749	-0.001807036
-235	217,883	217,196	687	0.003161342	0.002745623
-236	215,624	214,646	978	0.004554211	0.003908891
-237	213,396	211,809	1,587	0.007490513	0.006344151
-238	210,000	208,485	1,515	0.007264844	0.006056457
-239	207,212	205,426	1,786	0.008695366	0.007142674
-240	203,516	202,360	1,156	0.005712674	0.004622551
-241	200,847	198,993	1,854	0.009315374	0.007412345
-242	196,947	195,554	1,393	0.007121989	0.005569107
-243	194,014	191,887	2,127	0.011085703	0.00850602
-244	189,141	187,726	1,415	0.007536351	0.00565722
-245	184,759	183,640	1,119	0.00609304	0.004474236
-246	181,135	179,860	1,275	0.007089081	0.005098496
-247	177,325	176,129	1,196	0.006787666	0.004780451
-248	174,387	172,565	1,822	0.010558295	0.007285579
-249	170,918	169,311	1,607	0.009490897	0.006425546
-250	168,005	166,300	1,705	0.010251347	0.00681696

Table B.6 - (Continued)

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-251	164,565	163,361	1,204	0.007370714	0.004814769
-252	162,124	160,481	1,643	0.010234956	0.006567909
-253	158,765	157,631	1,134	0.007195213	0.004535267
-254	156,321	154,611	1,710	0.011058599	0.006836882
-255	152,700	151,497	1,203	0.007943563	0.004812126
-256	150,098	148,330	1,768	0.011920749	0.0070705
-257	146,353	145,065	1,288	0.008878981	0.005150428
-258	143,676	141,849	1,827	0.01287843	0.007304774
-259	139,938	138,598	1,340	0.009668451	0.005358354
-260	137,345	135,199	2,146	0.015872434	0.008580935
-261	133,254	131,581	1,673	0.012715644	0.006690354
-262	130,078	127,796	2,282	0.017853593	0.009123478
-263	125,382	123,787	1,595	0.012888848	0.006379795
-264	122,008	119,248	2,760	0.023145069	0.011036393
-265	116,613	114,510	2,103	0.018368913	0.008410938
-266	112,481	109,576	2,905	0.026513962	0.011617365
-267	106,528	104,350	2,178	0.020875642	0.008710636
-268	101,761	98,332	3,429	0.034876725	0.013713494
-269	93,911	91,260	2,651	0.029047441	0.010600001
-270	85,520	80,635	4,885	0.060578749	0.019532663
-271	73,163	69,137	4,026	0.058229619	0.016098005
-272	63,294	57,012	6,282	0.110190383	0.025120457
-273	50,720	45,669	5,051	0.110609705	0.020199113

Table B.6 - (Continued)

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-274	36,416	34,430	1,986	0.057670295	0.007939749
-275	27,525	22,315	5,210	0.233493018	0.020834753
-276	15,614	13,115	2,499	0.190546558	0.009992795
-277	10,282	5,705	4,577	0.802241708	0.018301153
-278	1,137	441	696	1.577398558	0.002781619
-279	20	0	20	20	8.18394E-05
-280	0	0	0	0	0

Table B.7 - Scenario 3 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations versus United States Bureau of Reclamation (USBR) report calculations

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-227	9,350,863	9,318,560	32,303	0.00346656	0.00346656
-228	7,471,084	7,391,803	79,281	0.01072559	0.00850791
-229	7,247,612	7,160,886	86,726	0.01211105	0.00930679
-230	7,019,216	6,932,056	87,160	0.01257346	0.00935337
-231	6,799,307	6,705,285	94,022	0.01402204	0.01008973
-232	6,573,237	6,480,546	92,691	0.01430291	0.00994689
-233	6,355,583	6,257,802	97,781	0.01562546	0.01049315
-234	6,131,895	6,037,084	94,811	0.01570471	0.01017439
-235	5,916,511	5,818,624	98,146	0.01686754	0.01053230
-236	5,696,013	5,602,705	93,567	0.01670026	0.01004089
-237	5,484,892	5,389,422	95,729	0.01776233	0.01027291
-238	5,269,591	5,179,311	90,539	0.01748095	0.00971601
-239	5,064,348	4,972,368	92,235	0.01854942	0.00989794
-240	4,855,569	4,768,461	87,363	0.01832091	0.00937511
-241	4,656,625	4,567,742	89,137	0.01951450	0.00956556
-242	4,454,356	4,370,492	84,112	0.01924550	0.00902632
-243	4,261,947	4,176,760	85,432	0.02045423	0.00916799
-244	4,067,027	3,986,863	80,348	0.02015317	0.00862235
-245	3,882,610	3,801,204	81,536	0.02145002	0.00874984
-246	3,696,308	3,619,455	76,841	0.02123008	0.00824605
-247	3,519,695	3,441,478	78,138	0.02270478	0.00838520
-248	3,346,618	3,267,126	79,397	0.02430181	0.00852032
-249	3,171,326	3,096,217	75,010	0.02422632	0.00804952

Table B.7 - (Continued)

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-250	3,004,775	2,928,427	76,248	0.02603733	0.00818243
-251	2,835,648	2,763,584	71,967	0.02604126	0.00772300
-252	2,674,860	2,601,679	73,084	0.02809113	0.00784285
-253	2,511,662	2,442,615	68,950	0.02822778	0.00739917
-254	2,356,587	2,286,483	70,007	0.03061777	0.00751264
-255	2,199,412	2,133,403	65,912	0.03089522	0.00707319
-256	2,050,383	1,983,488	66,797	0.03367671	0.00716821
-257	1,899,591	1,836,777	62,717	0.03414507	0.00673032
-258	1,756,843	1,693,324	63,423	0.03745463	0.00680608
-259	1,612,611	1,553,100	59,414	0.03825522	0.00637590
-260	1,476,131	1,416,184	59,851	0.04226251	0.00642283
-261	1,338,470	1,282,788	55,586	0.04333253	0.00596513
-262	1,208,832	1,153,081	55,654	0.04826556	0.00597239
-263	1,078,842	1,027,263	51,481	0.05011441	0.00552453
-264	957,056	905,703	51,257	0.05659306	0.00550047
-265	835,725	788,829	46,799	0.05932711	0.00502212
-266	722,943	676,759	46,090	0.06810352	0.00494601
-267	611,540	569,758	41,687	0.07316690	0.00447359
-268	508,973	468,355	40,522	0.08651965	0.00434852
-269	409,268	373,465	35,708	0.09561144	0.00383187
-270	320,157	287,057	33,003	0.11497003	0.00354164
-271	237,829	212,239	25,513	0.12020795	0.00273785
-272	170,581	149,183	21,324	0.14293827	0.00228833

Table B.7 - (Continued)

Elevation	Total Vol (af)	USBR Vol (af)	Difference (af)	% Difference	% Difference of Total
-273	115,739	97,925	17,750	0.18125667	0.00190475
-274	71,087	57,804	13,261	0.22941608	0.00142309
-275	39,680	30,013	9,658	0.32179189	0.00103642
-276	17,720	12,382	5,343	0.43152282	0.00057338
-277	4,997	2,828	2,169	0.76703094	0.00023278
-278	410	52	361	6.94325578	0.00003875
-279	1	0	1	0.00000000	0.00000007
-280	0	0	0	0.00000000	0.00000000

Table B.8 - Scenario 3 Salton Sea TIN calculated elevation (ft) and surface area (SA) correlations versus United States Bureau of Reclamation (USBR) report calculations

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-227	234,830	250,082	-15,252	-0.06098872	-0.06098872
-228	229,660	231,973	-2,313	-0.00997208	-0.00924998
-229	225,264	229,868	-4,604	-0.02002948	-0.01841050
-230	223,913	227,798	-3,885	-0.01705606	-0.01553625
-231	222,924	225,750	-2,826	-0.01251912	-0.01130106
-232	221,626	223,734	-2,108	-0.00942069	-0.00842815
-233	220,621	221,752	-1,131	-0.00509862	-0.00452104
-234	219,193	219,640	-447	-0.00203726	-0.00178927
-235	217,886	217,196	690	0.00317817	0.00276024
-236	215,593	214,646	947	0.00441337	0.00378801
-237	213,326	211,809	1,517	0.00716381	0.00606744
-238	209,953	208,485	1,468	0.00703981	0.00586885
-239	207,086	205,426	1,660	0.00808142	0.00663836
-240	203,479	202,360	1,119	0.00552905	0.00447397
-241	200,752	198,993	1,759	0.00883997	0.00703406
-242	196,918	195,554	1,364	0.00697532	0.00545442
-243	194,013	191,887	2,126	0.01108018	0.00850178
-244	189,109	187,726	1,383	0.00736739	0.00553039
-245	184,705	183,640	1,065	0.00579929	0.00425853
-246	181,006	179,860	1,146	0.00636935	0.00458087
-247	177,301	176,129	1,172	0.00665410	0.00468638
-248	174,376	172,565	1,811	0.01049564	0.00724234
-249	170,914	169,311	1,603	0.00947038	0.00641166
-250	168,004	166,300	1,704	0.01024466	0.00681251

Table B.8 - (Continuted)

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-251	164,562	163,361	1,201	0.00734996	0.00480122
-252	162,122	160,481	1,641	0.01022797	0.00656343
-253	158,765	157,631	1,134	0.00719368	0.00453430
-254	156,321	154,611	1,710	0.01105761	0.00683627
-255	152,700	151,497	1,203	0.00794262	0.00481156
-256	150,098	148,330	1,768	0.01192112	0.00707072
-257	146,354	145,065	1,289	0.00888307	0.00515280
-258	143,676	141,849	1,827	0.01288101	0.00730624
-259	139,939	138,598	1,341	0.00967288	0.00536081
-260	137,343	135,199	2,144	0.01585862	0.00857346
-261	133,259	131,581	1,678	0.01275042	0.00670865
-262	130,083	127,796	2,287	0.01789935	0.00914686
-263	125,384	123,787	1,597	0.01290514	0.00638786
-264	122,011	119,248	2,763	0.02317156	0.01104903
-265	116,608	114,510	2,098	0.01832197	0.00838944
-266	112,481	109,576	2,905	0.02651388	0.01161733
-267	106,531	104,350	2,181	0.02089922	0.00872047
-268	101,770	98,332	3,438	0.03496493	0.01374818
-269	93,877	91,260	2,617	0.02867220	0.01046307
-270	85,560	80,635	4,925	0.06107432	0.01969245
-271	73,184	69,137	4,047	0.05852875	0.01618070
-272	63,224	57,012	6,212	0.10896372	0.02484081
-273	50,954	45,669	5,285	0.11571427	0.02113129

Table B.8 - (Continuted)

Elevation	Total SA (ac)	USBR SA (ac)	Diff. (ac)	% Diff.	% Diff. of Total
-274	36,386	34,430	1,956	0.05680444	0.00782054
-275	27,627	22,315	5,312	0.23804315	0.02124076
-276	15,727	13,115	2,612	0.19915809	0.01044441
-277	10,199	5,705	4,494	0.78781499	0.01797204
-278	992	441	551	1.24861198	0.00220183
-279	67	0	67	67	0.00026733
-280	0	0	0	0	0

Table B.9 - Imperial and Coachella Valley weather stations and associated data

Station Number	Name	Date	Evap (mm)	ETo (mm)	Precip (mm)	Sol Rad (W.sq.m)	Avg. Vap (kPa)	Air Temp (°C)	Rel Humid (%)	Dew Pt (°C)	Avgw Spd (m/s)	Wind Run (Km)	Soil Temp (°C)
NCDC 041048	Brawley 2 SW	1/1/80 - 12/31/04	Yes	No	Yes	Yes	No	Yes	No	No	No	No	Yes
NCDC 042713	El Centro 2 SSW	1/1/80 - 12/31/04	No	No	Yes	No	No	Yes	No	No	No	No	No
NCDC 044223	Imperial	1/1/80 - 12/31/04	No	No	Yes	No	No	Yes	No	No	No	No	No
NCDC 044259	Indio Fire Station	1/1/80 - 12/31/04	Yes*	No	Yes	No	No	Yes	No	No	No	No	Yes
NCDC 045502	Mecca Fire Stn	1/1/80 - 12/31/04	No	No	Yes	No	No	Yes	No	No	No	No	No
NCDC 046197	Niland	1/1/80 - 12/31/04	No	No	Yes	No	No	No	No	No	No	No	No
NCDC 048893	Thermal Fire Stn 39	1/1/80 - 12/31/04	No	No	Yes	No	No	Yes	No	No	No	No	No
CIMIS 17	El Centro	1/1/82 - 12/31/87	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 18	Westmorland	11/11/82 - 4/9/86	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 24	Thermal	1/1/86 - 12/31/98	No	Yes	No	No	No	No	No	No	No	No	No
CIMIS 36	BLYTHE.A	1/1/83 - 1/1/89	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 41	Calipatria/ Mulberry	7/17/83 - 12/31/04	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CIMIS 50	THERMAL.A	1/1/82 - 12/31/04	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CIMIS 68	Seeley	5/29/87 - 12/31/04	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* only 2 years of data available

Table B.9 - (Continued)

Station Number	Name	Date	Evap (mm)	ETo (mm)	Precip (mm)	Sol Rad (W.sq.m)	Avg. Vap (kPa)	Air Temp (°C)	Rel Humid (%)	Dew Pt (°C)	Avgw Spd (m/s)	Wind Run (Km)	Soil Temp (°C)
CIMIS 87	El Centro/Meloland	1/1/89 - 12/31/04	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 127	Salton Sea West (Salton City)	11/21/94 - 12/31/04	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
CIMIS 128	Salton Sea East (Niland)	11/17/94 - 12/31/04	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
CIMIS 136	Oasis	1/1/97 - 12/31/04	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 141	Mecca	5/5/98 - 12/31/04	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CIMIS 154	Salton Sea North	10/98 - 12/03	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
CIMIS 162	Indio.A	1/1/00 - 12/31/04	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes
CIMIS 180	Westmorland West	11/8/01 - 7/21/03	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CIMIS 181	Westmorland North	3/24/04 - 12/31/04	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table B.10 - Probability distributions fit to the historical climate datasets

1. Beta	16. Laplace	31. Chi-Squared
2. Erlang	17. Logistic	32. Chi-Squared (2P)
3. Erlang (2P)	18. Lognormal	33. Pareto
4. Error Function	19. Lognormal (2P)	34. Student's t
5. Exponential	20. Normal	
6. Exponential (2P)	21. Pert	
7. Gamma	22. Phased Bi-Exponential	
8. Gamma (2P)	23. Phased Bi-Weibull	
9. Gen. Extreme Value	24. Rayleigh	
10. Gen. Logistic	25. Rayleigh (2P)	
11. Gen. Pareto	26. Triangular	
12. Gumbel Max	27. Uniform	
13. Gumbel Min	28. Wakeby	
14. Inv. Gaussian	29. Weibull	
15. Inv. Gaussian (2P)	30. Weibull (2P)	

Table B.11 - Binomial and multinomial logistic regression models used for the analyses of the relationships between precipitation and evapotranspiration

1.) $(Logit\ Y_{1,.........12})\ Month = Constant + X_1\ Prcp$
2.) $(Logit\ Y_{1,.........12})\ Month = Constant + X_1\ Eto$
3.) $(Logit\ Y_{0,...4})\ PrcpAmt = Constant + X_1\ Eto$
4.) $(Logit\ Y_{0,....5})\ CatEvent = Constant + X_1\ Eto$
5.) $(Logit\ Y_{0,1})\ RainEvent = Constant + X_1\ Eto$
6.) $(Logit\ Y_{0,...4})\ CatVol = Constant + X_1\ Eto$
7.) $(Logit\ Y_{0,..3})\ EtoFirst = Constant + X_1\ PrcpAmt$
8.) $(Logit\ Y_{0,..3})\ EtoFirst = Constant + X_1 Eto$
9.) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1\ PrcpAmt + X_2\ CatEvent$
10.) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1 Eto$
11.) $(Logit\ Y_{0,..3})\ Etolev2 = Constant + X_1\ PrcpAmt + X_2\ CatVol + X_3\ CatEvent + X_4$ *Month*
12.) $(Logit\ Y_{0,.2})\ Prcponafter = Constant + X_1\ Eto$
13.) $(Logit\ Y_{0,.2})\ Prcponafter = Constant + X_1\ EtoPerCh$
14.) $(Logit\ Y_{0,.2})\ Prcpbefafter = Constant + X_1\ Eto$
15.) $(Logit\ Y_{0,.2})\ Prcpbefafter = Constant + X_1\ EtoPerCh$
16.) $(Logit\ Y_{0,1})\ PrcpOn = Constant + X_1\ EtoPerCh$

Table B.12 - Variables used in the regression analyses to determine the relationships between precipitation (Prcp) and evapotranspiration (Eto)

1.) '*Month*'- denoting the month of the year, e.g. 1 = Month 1 (January).

2.) '*Rain Event*'- denoting the presence (1) or absence (0) of a Prcp event.

3.) '*Eto* $\leq$ *0.21*'- denoting days with an Eto > 0.21 or $\leq$ 0.21 inches with a 0 and 1, respectively.

4.) '*Prcp*'- a variable representing the daily historic Prcp data (1982 - 2004).

5.) '*Eto'* - a variable representing the daily historic Eto data (1982 - 2004).

6.) '*CatEvent*'- values 0 through 7 denoting the number of days of consecutive Prcp, i.e. no Prcp = 0, 1 day = 1, and so on.

7.) '*CatVol*'- a value of 0 for no Prcp, 1 for a single event, 2 for a consecutive event of < volume, 3 for a consecutive event of = volume, and 4 for a consecutive event of > volume.

8.) '*PrcpAmt*'- a value of 0 for no Prcp, amounts ≤ 0.1 inches = 1, ≤ 0.2 inches but > 0.1 inches = 2, Prcp amounts ≤ 0.5 inches but > 0.2 inches = 3, and > 0.5 inches = 4.

9.) '*Prcponafter*'- a value of 1 for a single Prcp event or the first day in a series of events, and 2 for the day after a single Prcp event or after the last day in a series of events, and 0 for all other days.

10.) '*Prcpbefafter*'- a value of 1 for a day before a Prcp event or series of events, 2 for the day immediately after a single Prcp event or the last day in a series of events, and 0 for all other days.

11.) '*PrcpOn*'- a value of 1 for a single Prcp event or the first day in a series of days having Prcp events, and 0 for all other days.

Table B.12 - (Continued)

12.) '*EtoAmt*'- a value of 1 when Eto was ≤ 0.11 inches, 2 when Eto was > 0.11 and ≤ 0.21 inches, 3 when Eto was > 0.21 and ≤ 0.32 inches, 4 when Eto was > 0.32 and ≤ 0.41 inches, 5 when Eto was > 0.41 and ≤ 0.5 inches, and 6 when Eto was > 0.5 inches.
13.) '*EtoPerCh*'- a variable representing the percent change in Eto from one day to the next.
14.) '*EtoFirst*'- where Prcp is absent or a consecutive day (Other) = 0, Eto the day of the event < the day before the event = 1, Eto the day before the event = Eto the day of the event = 2, and Eto the day of the event > Eto the day before = 3.
15.) '*Etolev2*'- where Prcp event is absent (Other) = 0, Eto after a Prcp event < Eto the day of a Prcp event = 1, Eto after a Prcp event = Eto the day of a Prcp event = 2, and Eto after a Prcp event > Eto the day of a Prcp event = 3.
16.) '*EtoOne*'- measuring if Eto before a series of Prcp events = Eto the day after, where the series of Prcp events is absent or ongoing (Other) = 0, Eto the day after a series of Prcp events < Eto the day before the Prcp events = 1, Eto the day after a series of Prcp events = Eto the day before the Prcp events = 2, and Eto the day after a series of Prcp events > Eto the day before the Prcp events = 3.
17.) '*EtoTwo*'- measuring if Eto the first day in a series of Prcp events = Eto the day after, where the series of Prcp events is absent or ongoing (Other) = 0, Eto the day after the series of Prcp events < Eto the first day of the series = 1, Eto the day after a series of Prcp events = Eto the first day of the series = 2, and Eto the day after the series of Prcp events > Eto the first day of the series = 3.

Table B.13 - Precipitation observation data by month

	Thermal-Indio	**Brawley-Calipatria**	**Averaged**
January	775	713	775
February	707	667	707
March	775	713	775
April	750	690	750
May	775	713	775
June	750	690	750
July	775	713	775
August	775	713	775
September	750	690	750
October	775	713	775
November	750	690	750
December	775	696	775

Table B.14 - Evapotranspiration (Eto) observation data by month

	Thermal-Indio	**Brawley-Calipatria**	**Averaged**
January	713	709	775
February	675	667	707
March	715	704	775
April	690	683	750
May	713	708	775
June	660	690	750
July	688	711	773
August	713	709	771
September	690	685	745
October	712	713	775
November	696	687	748
December	728	695	775

Table B.15 - Month 1: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1	23	N/A	N/A
Error Function	0.499	6	239.207	9
Exponential	0.861	20	325.908	14
Exponential (2P)	0.861	12	15530.772	21
Gamma	0.861	18	1272.377	17
Gamma	0.861	19	-1.316	*1 (0.2)
Gen. Extreme Value	0.575	11	255.909	11
Gen. Logistic	0.560	10	242.929	10
Gen. Pareto	0.552	8	236.274	7
Gumbel Max	0.479	4	223.683	3
Gumbel Min	0.511	7	296.839	12
Inv. Gaussian	0.861	16	1233.376	16
Inv. Gaussian	0.861	17	30.561	2
Laplace	0.488	5	235.615	5
Logistic	0.454	3	228.704	4
Lognormal	0.861	15	1288.238	19
Lognormal	0.861	14	1288.234	18

Table B.15 - (Continued)

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Normal	0.443	2	238.511	8
Pert	0.862	21	17194.693	22
Rayleigh	0.896	22	4403.489	20
Rayleigh	0.861	13	693.278	15
Uniform	0.439	1	301.859	13
Wakeby	0.552	9	236.274	6
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.16 - Month 2: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1	24	N/A	N/A
Error Function	0.499	5	208.234	7
Exponential	0.842	21	345.823	14
Exponential (2P)	0.842	12	13671.062	22
Gamma	0.842	19	1138.054	18
Gamma	0.842	20	20.653	1
Gen. Extreme Value	0.560	11	219.587	11
Gen. Logistic	0.546	10	209.308	8
Gen. Pareto	0.536	8	201.932	5
Gumbel Max	0.451	3	191.857	3
Gumbel Min	0.514	7	295.120	12
Inv. Gaussian	0.842	17	1074.536	17
Inv. Gaussian	0.842	18	61.572	2
Laplace	0.500	6	217.743	10
Logistic	0.462	4	205.606	6
Lognormal	0.842	16	1147.798	19
Lognormal	0.842	15	1147.799	20
Normal	0.448	2	210.332	9

Table B.16. (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Phased Bi-Exponential	0.842	13	539.208	15
Rayleigh	0.842	14	700.133	16
Rayleigh	0.880	23	3493.108	21
Triangular	0.850	22	15393.761	23
Uniform	0.423	1	325.072	13
Wakeby	0.536	9	201.932	4
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Pert	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.17 - Month 3: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	6	250.670	8
Exponential	0.867	20	463.414	14
Exponential (2P)	0.867	12	15707.734	21
Gamma	0.867	18	1294.814	19
Gamma	0.867	19	13.478	1
Gen. Extreme Value	0.576	11	256.727	11
Gen. Logistic	0.561	10	243.407	7
Gen. Pareto	0.554	8	237.878	5
Gumbel Max	0.480	4	234.060	3
Gumbel Min	0.521	7	326.575	13
Inv. Gaussian	0.867	16	1278.837	16
Inv. Gaussian	0.867	17	57.659	2
Laplace	0.494	5	251.358	9
Logistic	0.459	3	242.837	6
Lognormal	0.867	15	1290.523	18
Lognormal	0.867	14	1290.520	17
Normal	0.451	2	252.293	10

Table B.17 - (Continued)

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Pert	0.868	21	17177.756	22
Rayleigh	0.916	22	5051.283	20
Rayleigh	0.867	13	955.691	15
Uniform	0.439	1	325.728	12
Wakeby	0.554	9	237.878	4
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.18 - Month 4: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	1	272.333	8
Exponential	0.963	22	-5.132	*3 (0.2)
Exponential (2P)	0.963	12	17419.287	21
Gamma	0.963	20	1421.664	17
Gamma	0.963	21	2.132	*5 (0.05)
Gen. Extreme Value	0.656	11	352.404	16
Gen. Logistic	0.639	10	332.435	15
Gen. Pareto	0.636	8	329.748	14
Gumbel Max	0.516	4	264.787	6
Gumbel Min	0.582	7	326.605	12
Inv. Gaussian	0.963	18	1425.818	18
Inv. Gaussian	0.963	19	1.915	*4 (0.1)
Laplace	0.544	6	272.624	9
Logistic	0.519	5	266.730	7
Lognormal	0.963	17	1430.690	19
Lognormal	0.963	16	1430.700	20
Normal	0.512	3	275.558	10

Table B.18 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.963	13	19508.548	22
Rayleigh	0.963	14	-14.000	*2 (0.2)
Rayleigh	0.963	15	-17.490	*1 (0.2)
Uniform	0.499	2	312.495	11
Wakeby	0.636	9	329.748	13
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.19 - Month 5: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	1	289.575	9
Exponential	0.977	22	-9.039	*3 (0.2)
Exponential (2P)	0.977	12	18272.319	21
Gamma	0.977	20	1492.959	19
Gamma	0.977	21	1.991	*4 (0.05)
Gen. Extreme Value	0.667	11	381.131	16
Gen. Logistic	0.648	10	359.044	15
Gen. Pareto	0.647	8	357.744	14
Gumbel Max	0.533	5	287.857	7
Gumbel Min	0.582	7	327.437	12
Inv. Gaussian	0.977	18	1526.886	20
Inv. Gaussian	0.977	19	3.982	5
Laplace	0.534	6	287.942	8
Logistic	0.516	4	284.855	6
Lognormal	0.977	17	1481.462	17
Lognormal	0.977	16	1481.472	18
Normal	0.511	3	291.591	10

Table B.19 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.977	13	20887.693	22
Rayleigh	0.977	14	-11.613	*2 (0.2)
Rayleigh	0.977	15	-11.995	*1 (0.2)
Uniform	0.502	2	308.436	11
Wakeby	0.647	9	357.744	13
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.20 - Month 6: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	1	291.472	8
Exponential	0.995	22	-4.000	*1 (0.2)
Exponential (2P)	0.995	12	16923.634	20
Gamma	0.995	20	1517.306	17
Gamma	0.995	21	-0.062	*4 (0.2)
Gen. Extreme Value	0.682	11	393.502	15
Gen. Logistic	0.662	10	370.590	14
Gen. Pareto	0.662	8	370.160	13
Gumbel Max	0.543	6	291.208	7
Gumbel Min	0.590	7	321.764	11
Inv. Gaussian	0.995	18	1456.722	16
Inv. Gaussian	0.995	19	-0.612	*3 (0.2)
Laplace	0.537	5	289.132	6
Logistic	0.523	4	286.499	5
Lognormal	0.995	17	1539.217	19
Lognormal	0.995	16	1539.198	18
Normal	0.519	3	292.919	9

Table B.20 - (Continued)

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Pert	0.995	13	19862.937	21
Rayleigh	0.995	14	-1.000	*2 (0.2)
Rayleigh	0.995	15	N/A	N/A
Uniform	0.513	2	295.382	10
Wakeby	0.662	9	370.160	12
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.21 - Month 7: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	2	287.604	9
Exponential	0.966	22	106.674	3
Exponential (2P)	0.966	12	18673.470	21
Gamma	0.966	20	1476.606	20
Gamma	0.966	21	3.836	*1 (0.01)
Gen. Extreme Value	0.658	11	366.602	16
Gen. Logistic	0.639	10	345.435	15
Gen. Pareto	0.638	8	343.746	14
Gumbel Max	0.528	5	283.014	7
Gumbel Min	0.576	7	326.050	12
Inv. Gaussian	0.966	18	1470.608	17
Inv. Gaussian	0.966	19	13.963	2
Laplace	0.531	6	284.739	8
Logistic	0.510	4	281.126	6
Lognormal	0.966	17	1476.386	19
Lognormal	0.966	16	1476.383	18
Normal	0.505	3	289.878	10

Table B.21 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.966	13	21099.795	22
Rayleigh	0.966	14	163.572	5
Rayleigh	0.966	15	145.106	4
Uniform	0.494	1	311.124	11
Wakeby	0.638	9	343.746	13
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.22 - Month 8: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	24	N/A	N/A
Error Function	0.499	4	268.954	7
Exponential	0.942	23	145.875	3
Exponential (2P)	0.942	12	18228.984	21
Gamma	0.942	21	1416.653	18
Gamma	0.942	22	-4.290	*1 (0.2)
Gen. Extreme Value	0.639	11	337.831	15
Gen. Logistic	0.621	10	318.740	14
Gen. Pareto	0.618	8	315.509	12
Gumbel Max	0.520	6	267.993	6
Gumbel Min	0.558	7	310.953	10
Inv. Gaussian	0.942	19	1403.799	17
Inv. Gaussian	0.942	20	8.085	2
Laplace	0.517	5	269.215	8
Logistic	0.494	3	265.849	5
Lognormal	0.942	18	1438.606	20
Lognormal	0.942	17	1438.603	19
Normal	0.488	2	270.664	9

Table B.22 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.942	13	20668.391	22
Rayleigh	0.942	16	251.572	4
Rayleigh	0.942	15	631.753	16
Triangular	0.942	14	21489.207	23
Uniform	0.475	1	317.463	13
Wakeby	0.618	9	315.509	11
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.23 - Month 9: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	4	252.347	6
Exponential	0.920	22	202.031	3
Exponential (2P)	0.920	12	16688.500	21
Gamma	0.920	20	1337.867	17
Gamma	0.920	21	-1.265	*1 (0.2)
Gen. Extreme Value	0.621	11	302.803	12
Gen. Logistic	0.605	10	286.116	11
Gen. Pareto	0.600	8	281.870	10
Gumbel Max	0.506	5	246.229	4
Gumbel Min	0.549	7	303.430	13
Inv. Gaussian	0.920	18	1326.964	16
Inv. Gaussian	0.920	19	14.327	2
Laplace	0.515	6	252.719	8
Logistic	0.487	3	247.514	5
Lognormal	0.920	17	1352.442	19
Lognormal	0.920	16	1352.429	18
Normal	0.479	2	252.385	7

Table B.23 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.920	13	18756.181	22
Rayleigh	0.920	14	1804.307	20
Rayleigh	0.920	15	383.302	15
Uniform	0.463	1	305.444	14
Wakeby	0.600	9	281.870	9
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.24 - Month 10: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	3	279.142	8
Exponential	0.954	22	166.614	4
Exponential (2P)	0.954	12	18458.914	21
Gamma	0.954	20	1448.894	18
Gamma	0.954	21	1.159	*2 (0.2)
Gen. Extreme Value	0.648	11	350.524	16
Gen. Logistic	0.629	10	330.512	15
Gen. Pareto	0.627	8	328.019	14
Gumbel Max	0.524	5	275.892	6
Gumbel Min	0.567	7	322.358	12
Inv. Gaussian	0.954	18	1438.161	17
Inv. Gaussian	0.954	19	15.389	3
Laplace	0.524	6	278.350	7
Logistic	0.502	4	274.589	5
Lognormal	0.954	17	1458.622	20
Lognormal	0.954	16	1458.619	19
Normal	0.496	2	281.276	9

Table B.24 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.954	13	20978.832	22
Rayleigh	0.954	14	-14.835	*1 (0.2)
Rayleigh	0.954	15	287.085	10
Uniform	0.485	1	321.347	11
Wakeby	0.627	9	328.019	13
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.25 - Month 11: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	3	262.945	8
Exponential	0.935	22	122.428	3
Exponential (2P)	0.935	12	17261.911	21
Gamma	0.935	20	1372.931	18
Gamma	0.935	21	6.416	1
Gen. Extreme Value	0.633	11	318.615	14
Gen. Logistic	0.616	10	300.914	12
Gen. Pareto	0.612	8	297.101	11
Gumbel Max	0.503	4	251.029	5
Gumbel Min	0.566	7	324.834	15
Inv. Gaussian	0.935	18	1357.209	17
Inv. Gaussian	0.935	19	15.009	2
Laplace	0.533	6	262.165	7
Logistic	0.504	5	255.513	6
Lognormal	0.935	17	1377.785	20
Normal	0.496	2	266.718	9

Table B.25 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.935	13	19062.166	22
Rayleigh	0.935	14	486.014	16
Rayleigh	0.935	15	211.195	4
Uniform	0.479	1	315.101	13
Wakeby	0.612	9	297.101	10
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.26 - Month 12: Thermal-Indio and Brawley-Calipatria (TIBC) averaged precipitation distribution fitting results

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Beta	1.000	23	N/A	N/A
Error Function	0.499	6	253.781	6
Exponential	0.884	22	324.035	14
Exponential (2P)	0.884	12	16199.526	21
Gamma	0.884	20	1316.002	19
Gamma	0.884	21	-4.989	*1 (0.2)
Gen. Extreme Value	0.591	11	273.720	11
Gen. Logistic	0.575	10	258.911	10
Gen. Pareto	0.569	8	254.033	8
Gumbel Max	0.497	5	243.394	3
Gumbel Min	0.520	7	308.341	12
Inv. Gaussian	0.884	18	1320.260	20
Inv. Gaussian	0.884	19	23.237	2
Laplace	0.490	4	250.071	5
Logistic	0.460	3	246.097	4
Lognormal	0.884	17	1315.165	18
Lognormal	0.884	16	1315.152	17
Normal	0.451	2	256.151	9

Table B.26 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Pert	0.884	13	18083.113	22
Rayleigh	0.884	14	726.760	16
Rayleigh	0.884	15	642.146	15
Uniform	0.450	1	313.127	13
Wakeby	0.569	9	254.033	7
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Erlang	no fit			
Erlang (3P)	no fit			
Pareto	no fit			
Phased Bi-Exponential	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			
Triangular	no fit			
Weibull	no fit			
Weibull (3P)	no fit			

Table B.27 - Month 1: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Beta	0.058	*8 (0.01)	2.485	*6 (0.05)
Erlang	0.119	21	12.930	17
Erlang (3P)	0.057	*7 (0.01)	2.571	*7 (0.01)
Error Function	0.816	30	2301.925	30
Exponential	0.328	28	137.348	26
Exponential (2P)	0.309	27	120.133	25
Gamma	0.063	9	3.167	*8 (0.01)
Gamma (3P)	0.054	*6 (0.01)	2.201	*5 (0.05)
Gen. Extreme Value	0.051	*3 (0.01)	1.846	*2 (0.1)
Gen. Logistic	0.032	*2 (0.2)	0.532	*1 (0.2)
Gen. Pareto	0.097	16	158.984	28
Gumbel Max	0.064	10	3.822	*9 (0.01)
Gumbel Min	0.146	25	40.549	23
Inv. Gaussian	0.073	12	7.927	15
Inv. Gaussian (3P)	0.053	*5 (0.01)	2.042	*4 (0.05)
Laplace	0.100	17	6.782	14

Table B.27 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Logistic	0.075	14	4.061	10
Lognormal	0.105	18	11.099	16
Lognormal (3P)	0.053	*4 (0.01)	1.938	*3 (0.05)
Normal	0.078	15	5.839	13
Pareto	0.446	29	242.040	29
Pert	0.123	22	28.684	21
Phased Bi-Exponential	0.116	20	33.527	22
Rayleigh	0.140	23	25.330	20
Rayleigh (2P)	0.141	24	19.038	18
Triangular	0.195	26	72.679	24
Uniform	0.111	19	153.208	27
Wakeby	0.022	*1 (0.2)	23.943	19
Weibull	0.069	11	4.777	11
Weibull (3P)	0.074	13	5.685	12
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.28 - Month 2: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.043	*4 (0.1)	1.775	*5 (0.1)
Erlang	0.091	20	14.913	17
Erlang	0.086	17	13.442	14
Error Function	0.872	30	2749.074	30
Exponential	0.356	28	144.823	29
Exponential (2P)	0.356	29	140.604	28
Gamma	0.048	*8 (0.05)	7.329	10
Gamma	0.039	*3 (0.2)	6.288	9
Gen. Extreme Value	0.031	*1 (0.2)	0.807	*2 (0.2)
Gen. Logistic	0.038	*2 (0.2)	0.467	*1 (0.2)
Gen. Pareto	0.074	13	130.496	26
Gumbel Max	0.064	12	5.996	6
Gumbel Min	0.107	22	26.316	21
Inv. Gaussian	0.108	23	22.079	19
Inv. Gaussian	0.060	*11 (0.01)	11.843	13
Laplace	0.090	19	6.161	8
Logistic	0.051	*10 (0.01)	1.371	*3 (0.2)
Lognormal	0.074	14	13.819	15

Table B.28 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal	0.074	15	13.820	16
Normal	0.045	*6 (0.1)	1.583	4 (0.15)
Pert	0.105	21	17.359	18
Phased Bi-Exponential	0.145	25	52.203	25
Phased Bi-Weibull	0.048	*9 (0.05)	8.476	11
Rayleigh	0.159	26	37.335	23
Rayleigh	0.191	27	44.546	24
Triangular	0.132	24	24.075	20
Uniform	0.087	18	138.616	27
Wakeby	0.045	*7 (0.1)	32.164	22
Weibull	0.077	16	11.811	12
Weibull	0.045	*5 (0.1)	6.108	7
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Student's t	no fit			

Table B.29 - Month 3: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Beta	0.02722	*4 (0.2)	0.66228	*5 (0.2)
Erlang	0.11575	22	18.42902	17
Erlang (3P)	0.0277	*5 (0.2)	0.6377	*3 (0.2)
Error Function	0.93126	30	4581.3072	30
Exponential	0.38372	28	186.82653	28
Exponential (2P)	0.35915	27	168.50397	27
Gamma	0.04194	*11 (0.1)	1.96329	*9 (0.05)
Gamma (3P)	0.02908	*7 (0.2)	0.65676	*4 (0.2)
Gen. Extreme Value	0.02868	*6 (0.2)	2.82761	*12 (0.01)
Gen. Logistic	0.02387	*2 (0.2)	0.42012	*1 (0.2)
Gen. Pareto	0.07087	17	163.28055	26
Gumbel Max	0.06756	15	8.97117	16
Gumbel Min	0.10526	20	22.5672	18
Inv. Gaussian	0.0571	*14 (0.01)	5.16608	13
Inv. Gaussian (3P)	0.03908	*10 (0.15)	1.04096	*8 (0.2)
Laplace	0.07073	16	5.97203	14
Logistic	0.03893	*9 (0.15)	0.92838	*6 (0.2)
Lognormal	0.07311	18	6.79194	15

Table B.29 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal (3P)	0.02655	*3 (0.2)	0.60762	*2 (0.2)
Normal	0.03763	*8 (0.2)	1.02277	*7 (0.2)
Pareto	0.47644	29	267.65367	29
Pert	0.11202	21	27.13189	19
Phased Bi-Exponential	0.16302	24	73.58395	24
Rayleigh	0.19293	25	64.35811	23
Rayleigh (2P)	0.20795	26	59.15797	22
Triangular	0.15703	23	36.91604	21
Uniform	0.07834	19	124.04749	25
Wakeby	0.02286	*1 (0.2)	27.92342	20
Weibull	0.04744	*13 (0.05)	1.99225	*10 (0.05)
Weibull (3P)	0.04548	*12 (0.05)	2.40797	*11 (0.05)
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.30 - Month 4: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.046	*5 (0.05)	3.585	*7 (0.01)
Erlang	0.083	18	8.070	15
Erlang (3P)	0.064	13	4.843	11
Error Function	0.975	30	7005.953	30
Exponential	0.447	28	215.207	28
Exponential (2P)	0.415	27	193.935	27
Gamma	0.050	*8 (0.05)	3.441	*5 (0.01)
Gamma (3P)	0.047	*6 (0.05)	3.500	*6 (0.01)
Gen. Extreme Value	0.039	*2 (0.2)	2.420	*3 (0.05)
Gen. Logistic	0.020	*1 (0.2)	0.398	*1 (0.2)
Gen. Pareto	0.085	19	126.928	25
Gumbel Max	0.056	*10 (0.01)	5.764	13
Gumbel Min	0.122	21	34.063	18
Inv. Gaussian	0.050	*9 (0.01)	3.673	*8 (0.01)
Inv. Gaussian (3P)	0.061	12	4.434	10
Laplace	0.076	15	3.782	*9 (0.01)
Logistic	0.048	*7 (0.05)	2.332	*2 (0.05)
Lognormal	0.068	14	6.518	14

Table B.30 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal (3P)	0.045	*4 (0.05)	3.295	*4 (0.01)
Normal	0.059	*11 (0.01)	5.118	12
Pareto	0.507	29	268.990	29
Pert	0.180	23	59.720	20
Phased Bi-Exponential	0.177	22	75.533	22
Rayleigh	0.260	25	100.918	24
Rayleigh (2P)	0.276	26	93.068	23
Triangular	0.229	24	71.531	21
Uniform	0.109	20	136.054	26
Wakeby	0.041	*3 (0.15)	40.211	19
Weibull	0.077	16	8.910	16
Weibull (3P)	0.080	17	12.091	17
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.31 - Month 5: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.048	*12 (0.05)	3.556	*11 (0.01)
Erlang	0.042	*10 (0.1)	4.101	12
Erlang	0.050	*13 (0.01)	5.073	14
Error Function	0.992	29	10832.923	29
Exponential	0.473	27	242.440	28
Exponential (2P)	0.473	28	240.171	27
Gamma	0.034	*8 (0.2)	2.782	*4 (0.01)
Gamma	0.030	*6 (0.2)	2.992	*10 (0.01)
Gen. Extreme Value	0.027	*4 (0.2)	2.688	*3 (0.01)
Gen. Logistic	0.041	*9 (0.1)	1.208	*1 (0.2)
Gen. Pareto	0.071	17	137.241	24
Gumbel Max	0.043	*11 (0.1)	4.535	13
Gumbel Min	0.119	21	27.223	19
Inv. Gaussian	0.030	*7 (0.2)	2.953	*9 (0.01)
Inv. Gaussian	0.029	*5 (0.2)	2.890	*8 (0.01)
Laplace	0.103	20	9.531	15
Logistic	0.065	15	2.876	*7 (0.01)
Lognormal	0.027	*2 (0.2)	2.832	*6 (0.01)

Table B.31 - (Continued)

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Lognormal	0.027	*3 (0.2)	2.832	*5 (0.01)
Normal	0.052	*14 (0.01)	2.635	*2 (0.01)
Pert	0.212	23	81.818	20
Phased Bi-Exponential	0.191	22	99.002	22
Rayleigh	0.295	25	127.064	23
Rayleigh	0.358	26	152.233	25
Triangular	0.228	24	85.216	21
Uniform	0.082	18	154.122	26
Wakeby	0.026	*1 (0.2)	20.416	18
Weibull	0.084	19	10.268	16
Weibull	0.069	16	10.968	17
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.32 - Month 6: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.049	*9 (0.05)	2.229	*9 (0.05)
Erlang	0.083	15	9.016	15
Erlang (3P)	0.046	*5 (0.05)	2.115	*7 (0.05)
Error Function	0.993	30	9414.335	30
Exponential	0.473	29	229.827	29
Exponential (2P)	0.345	27	137.313	26
Gamma	0.061	12	3.612	*11 (0.01)
Gamma (3P)	0.052	*11 (0.01)	2.200	*8 (0.05)
Gen. Extreme Value	0.031	*3 (0.2)	0.968	*1 (0.2)
Gen. Logistic	0.038	*4 (0.2)	1.067	*2 (0.2)
Gen. Pareto	0.072	14	133.196	25
Gumbel Max	0.026	*2 (0.2)	1.126	*3 (0.2)
Gumbel Min	0.156	22	47.723	21
Inv. Gaussian	0.049	*8 (0.05)	2.240	*10 (0.05)
Inv. Gaussian (3P)	0.048	*7 (0.05)	1.863	*5 (0.1)
Laplace	0.125	20	13.763	16
Logistic	0.095	17	7.469	13
Lognormal	0.051	*10 (0.01)	1.952	*6 (0.05)

Table B.32 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal (3P)	0.047	*6 (0.05)	1.716	*4 (0.1)
Normal	0.086	16	7.809	14
Pareto	0.401	28	187.537	28
Pert	0.125	21	30.861	19
Phased Bi-Exponential	0.184	24	83.868	23
Rayleigh	0.299	26	116.964	24
Rayleigh (2P)	0.166	23	30.876	20
Triangular	0.213	25	65.344	22
Uniform	0.098	18	174.507	27
Wakeby	0.017	*1 (0.2)	19.986	17
Weibull	0.117	19	20.348	18
Weibull (3P)	0.066	13	7.113	12
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.33 - Month 7: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.213	22	61.298	19
Erlang	0.065	4	12.896	10
Erlang	0.123	16	25.325	15
Error Function	0.973	29	6540.494	29
Exponential	0.454	27	233.186	28
Exponential (2P)	0.454	28	226.684	27
Gamma	0.085	11	12.828	9
Gamma	0.094	13	17.594	13
Gen. Extreme Value	0.064	3	7.707	2
Gen. Logistic	0.047	*1 (0.05)	7.895	3
Gen. Pareto	0.098	14	157.394	24
Gumbel Max	0.078	8	10.523	5
Gumbel Min	0.155	19	52.625	18
Inv. Gaussian	0.078	9	12.126	8
Inv. Gaussian	0.083	10	16.513	11
Laplace	0.066	5	5.855	1
Logistic	0.092	12	9.794	4
Lognormal	0.076	7	11.620	7

Table B.33 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal	0.075	6	11.618	6
Normal	0.113	15	17.342	12
Pert	0.266	23	129.540	22
Phased Bi-Exponential	0.172	21	83.780	20
Rayleigh	0.282	24	117.964	21
Rayleigh	0.337	26	136.761	23
Triangular	0.323	25	170.951	25
Uniform	0.162	20	184.586	26
Wakeby	0.053	*2 (0.01)	33.337	16
Weibull	0.123	17	25.125	14
Weibull	0.148	18	41.593	17
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.34 - Month 8: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.126	21	27.147	18
Erlang	0.073	7	14.532	6
Erlang	0.159	22	39.060	20
Error Function	0.964	30	6623.462	30
Exponential	0.429	28	225.163	29
Exponential (2P)	0.429	29	216.703	28
Gamma	0.073	8	14.631	7
Gamma	0.080	10	15.049	8
Gen. Extreme Value	0.066	6	7.594	5
Gen. Logistic	0.047	*3 (0.05)	1.746	*2 (0.1)
Gen. Pareto	0.104	16	161.839	26
Gumbel Max	0.092	14	16.934	9
Gumbel Min	0.122	19	24.182	17
Inv. Gaussian	0.106	17	22.082	15
Inv. Gaussian	0.086	11	17.572	10
Laplace	0.035	*2 (0.2)	0.822	*1 (0.2)
Logistic	0.057	*4 (0.01)	2.494	*3 (0.05)
Lognormal	0.092	12	19.024	13

Table B.34 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal	0.092	13	19.026	14
Normal	0.076	9	6.191	4
Pert	0.177	24	62.335	21
Phased Bi-Exponential	0.165	23	85.222	23
Phased Bi-Weibull	0.060	5	19.012	12
Rayleigh	0.250	26	108.292	24
Rayleigh	0.306	27	128.029	25
Triangular	0.179	25	65.530	22
Uniform	0.117	18	164.918	27
Wakeby	0.029	*1 (0.2)	32.122	19
Weibull	0.124	20	23.779	16
Weibull	0.098	15	17.909	11
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Student's t	no fit			

Table B.35 - Month 9: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	**Kolmogorov Smirnov**		**Anderson Darling**	
	Statistic	Rank	Statistic	Rank
Beta	0.153	22	44.641	20
Erlang	0.052	*5 (0.01)	13.204	8
Erlang	0.070	13	14.785	10
Error Function	0.967	30	5725.715	30
Exponential	0.438	28	215.079	29
Exponential (2P)	0.438	29	204.776	28
Gamma	0.051	*4 (0.01)	13.197	7
Gamma	0.065	9	14.317	9
Gen. Extreme Value	0.052	*6 (0.01)	5.418	4
Gen. Logistic	0.035	*1 (0.2)	1.220	*1 (0.2)
Gen. Pareto	0.094	18	109.936	25
Gumbel Max	0.059	*7 (0.01)	9.427	6
Gumbel Min	0.121	20	31.354	18
Inv. Gaussian	0.089	17	21.428	15
Inv. Gaussian	0.061	8	15.938	11
Laplace	0.082	15	4.683	3
Logistic	0.049	*3 (0.05)	3.177	*2 (0.01)
Lognormal	0.065	10	16.245	12

Table B.35 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal	0.065	11	16.246	13
Normal	0.067	12	5.974	5
Pert	0.206	24	75.631	21
Phased Bi-Exponential	0.174	23	88.025	22
Phased Bi-Weibull	0.072	14	27.244	16
Rayleigh	0.254	26	100.580	24
Rayleigh	0.307	27	117.529	26
Triangular	0.245	25	88.653	23
Uniform	0.118	19	159.099	27
Wakeby	0.037	*2 (0.2)	36.471	19
Weibull	0.129	21	30.410	17
Weibull	0.089	16	21.056	14
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Student's t	no fit			

Table B.36 - Month 10: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.036	*8 (0.2)	1.298	*7 (0.2)
Erlang	0.093	19	12.979	17
Erlang (3P)	0.042	*10 (0.1)	2.391	*10 (0.05)
Error Function	0.937	30	4182.840	30
Exponential	0.407	28	184.858	28
Exponential (2P)	0.361	27	154.184	26
Gamma	0.026	*2 (0.2)	1.102	*4 (0.2)
Gamma (3P)	0.036	*7 (0.2)	1.257	*6 (0.2)
Gen. Extreme Value	0.025	*1 (0.2)	0.718	*2 (0.2)
Gen. Logistic	0.027	*3 (0.2)	0.563	*1 (0.2)
Gen. Pareto	0.062	15	129.639	25
Gumbel Max	0.045	*11 (0.05)	2.380	*9 (0.05)
Gumbel Min	0.133	21	35.068	18
Inv. Gaussian	0.039	*9 (0.15)	1.544	*8 (0.15)
Inv. Gaussian (3P)	0.034	*6 (0.2)	1.109	*5 (0.2)
Laplace	0.090	18	8.501	16
Logistic	0.060	14	3.654	*12 (0.01)
Lognormal	0.046	*12 (0.05)	2.702	*11 (0.01)

Table B.36 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal (3P)	0.033	*5 (0.2)	1.027	*3 (0.2)
Normal	0.064	16	4.378	13
Pareto	0.473	29	246.139	29
Pert	0.146	22	40.832	19
Phased Bi-Exponential	0.172	23	72.386	23
Rayleigh	0.204	25	62.197	22
Rayleigh (2P)	0.180	24	43.066	20
Triangular	0.251	26	79.627	24
Uniform	0.096	20	175.186	27
Wakeby	0.032	*4 (0.2)	43.717	21
Weibull	0.070	17	6.109	15
Weibull (3P)	0.058	*13 (0.01)	5.564	14
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.37 - Month 11: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.082	15	12.672	14
Erlang	0.088	17	12.733	15
Erlang	0.185	23	57.655	22
Error Function	0.877	29	2798.482	29
Exponential	0.368	27	159.551	27
Exponential (2P)	0.368	28	155.306	26
Gamma	0.039	*4 (0.15)	5.698	5
Gamma	0.048	*5 (0.05)	6.343	6
Gen. Extreme Value	0.035	*3 (0.2)	1.269	*2 (0.2)
Gen. Logistic	0.027	*1 (0.2)	0.340	*1 (0.2)
Gen. Pareto	0.080	14	146.455	25
Gumbel Max	0.049	*6 (0.05)	2.402	*3 (0.05)
Gumbel Min	0.139	21	37.797	18
Inv. Gaussian	0.065	10	8.669	12
Inv. Gaussian	0.054	*7 (0.01)	7.203	7
Laplace	0.104	18	7.244	8
Logistic	0.067	11	4.577	4
Lognormal	0.055	*9 (0.01)	7.333	10

Table B.37 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal	0.055	*8 (0.01)	7.333	9
Normal	0.076	12	8.541	11
Pert	0.201	25	74.428	23
Phased Bi-Exponential	0.139	20	54.354	21
Rayleigh	0.165	22	44.317	19
Rayleigh	0.194	24	50.409	20
Triangular	0.316	26	134.320	24
Uniform	0.117	19	186.526	28
Wakeby	0.031	*2 (0.2)	28.043	17
Weibull	0.083	16	11.166	13
Weibull	0.077	13	13.086	16
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Pareto	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.38 - Month 12: Thermal-Indio and Brawley-Calipatria (TIBC) averaged Eto distribution fitting results

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Beta	0.073	7	5.729	10
Erlang	0.243	25	71.427	22
Erlang (3P)	0.065	3	5.128	8
Error Function	0.830	30	2146.467	30
Exponential	0.336	28	142.771	26
Exponential (2P)	0.310	27	122.557	25
Gamma	0.079	9	6.186	11
Gamma (3P)	0.067	4	4.958	6
Gen. Extreme Value	0.077	8	3.050	*2 (0.01)
Gen. Logistic	0.059	2	1.233	*1 (0.2)
Gen. Pareto	0.112	17	170.863	27
Gumbel Max	0.080	10	3.741	*3 (0.01)
Gumbel Min	0.176	24	72.732	23
Inv. Gaussian	0.090	13	4.985	7
Inv. Gaussian (3P)	0.070	5	4.223	5
Laplace	0.125	20	12.529	15
Logistic	0.103	15	12.175	13
Lognormal	0.093	14	5.326	9

Table B.38 - (Continued)

Distribution	Kolmogorov Smirnov		Anderson Darling	
	Statistic	Rank	Statistic	Rank
Lognormal (3P)	0.070	6	3.814	*4 (0.01)
Normal	0.111	16	16.245	16
Pareto	0.455	29	243.019	29
Pert	0.149	23	32.418	21
Phased Bi-Exponential	0.113	18	25.504	18
Rayleigh	0.137	21	31.151	19
Rayleigh (2P)	0.123	19	20.018	17
Triangular	0.270	26	83.958	24
Uniform	0.147	22	211.550	28
Wakeby	0.035	*1 (0.2)	31.922	20
Weibull	0.090	12	12.036	12
Weibull (3P)	0.090	11	12.403	14
Chi-Squared	no fit			
Chi-Squared (2P)	no fit			
Phased Bi-Weibull	no fit			
Student's t	no fit			

Table B.39 - Brawley-Calipatria, Thermal-Indio, and averaged (TIBC) monthly precipitation “best” fit results using Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) test statistics

	Brawley-Calipatria	**Thermal-Indio**	**Averaged (TIBC)**
Month 1			
K-S	Uniform	Uniform	Uniform
A-D	Gamma	*Gamma (P= 0.2)	*Gamma (P= 0.2)
Month 2			
K-S	Uniform	Uniform	Uniform
A-D	Gamma	Gamma	Gamma
Month 3			
K-S	Uniform	Uniform	Uniform
A-D	*Gamma (P= 0.2)	*Rayleigh (P= 0.2)	Gamma
Month 4			
K-S	Error Function	Error Function	Error Function
A-D	*Exponential (P= 0.2)	*Exponential (P= 0.2)	*Rayleigh (P= 0.2)
Month 5			
K-S	Error Function	Error Function	Error Function
A-D	*Exponential (P= 0.2)	*Exponential (P= 0.2)	*Rayleigh (P= 0.2)
Month 6			
K-S	Error Function	Error Function	Error Function
A-D	*Inverse Gaussian (P= 0.2)	*Exponential (P= 0.2)	*Exponential (P= 0.2)

Table B.39 - (Continued)

	Brawley-Calipatria	Thermal-Indio	Averaged (TIBC)
Month 7			
K-S	Error Function	Error Function	Uniform
A-D	*Rayleigh (P= 0.2)	*Gamma (P=0.01)	*Gamma (P=0.01)
Month 8			
K-S	Uniform	Uniform	Uniform
A-D	Gamma	*Gamma (P=0.2)	*Gamma (P=0.2)
Month 9			
K-S	Error Function	Uniform	Uniform
A-D	*Gamma (P= 0.2)	*Gamma (P=0.2)	*Gamma (P=0.2)
Month 10			
K-S	Error Function	Uniform	Uniform
A-D	Gamma	Gamma	*Rayleigh (P= 0.2)
Month 11			
K-S	Uniform	Uniform	Uniform
A-D	*Gamma (P= 0.01)	*Gamma (P=0.2)	Gamma
Month 12			
K-S	Uniform	Uniform	Uniform
A-D	Gamma	*Gamma (P=0.2)	*Gamma (P=0.2)

* Significant P-value.

Table B.40 - Brawley-Calipatria, Thermal-Indio, and averaged (TIBC) monthly evapotranspiration “best” fit results using Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) test statistics

	Brawley-Calipatria	**Thermal-Indio**	**Averaged (TIBC)**
Month 1			
K-S	*Wakeby (P=0.1)	*Wakeby (P=0.01)	*Wakeby (P=0.2)
A-D	*Wakeby (P=0.01)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 2			
K-S	*Wakeby (P=0.1)	*Wakeby (P=0.01)	*General Extreme Value (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.15)	*General Logistic (P=0.2)
Month 3			
K-S	*Wakeby (P=0.01)	*General Logistic (P=0.01)	*Wakeby (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 4			
K-S	*Wakeby (P=0.01)	Wakeby	*General Logistic (P=0.2)
A-D	*Wakeby (P=0.01)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 5			
K-S	*Wakeby (P=0.01)	Wakeby	*Wakeby (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 6			
K-S	*Wakeby (P=0.01)	Wakeby	*Wakeby (P=0.2)
A-D	Wakeby	Wakeby	*General Extreme Value (P=0.2)

Table B.40 - (Continued)

	Brawley-Calipatria	Thermal-Indio	Averaged (TIBC)
Month 7			
K-S	*Wakeby (P=0.01)	Wakeby	*General Logistic (P=0.05)
A-D	*Wakeby (P=0.01)	Wakeby	Laplace
Month 8			
K-S	*Wakeby (P=0.01)	*Wakeby (P=0.05)	*Wakeby (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.01)	*Laplace (P=0.2)
Month 9			
K-S	*Wakeby (P=0.01)	Wakeby	*General Logistic (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 10			
K-S	*Wakeby (P=0.15)	Wakeby	*General Extreme Value (P=0.2)
A-D	*Wakeby (P=0.2)	Wakeby	*General Logistic (P=0.2)
Month 11			
K-S	*Wakeby (P=0.2)	Wakeby	*General Logistic (P=0.2)
A-D	*Wakeby (P=0.2)	*Wakeby (P=0.01)	*General Logistic (P=0.2)
Month 12			
K-S	Wakeby	Wakeby	*Wakeby (P=0.2)
A-D	*Wakeby (P=0.05)	*Wakeby (P=0.01)	*General Logistic (P=0.2)

* Significant P-value.

Table B.41 - Brawley-Calipatria precipitation descriptive statistics: months (1982-2004)

	January	February	March	April	May	June
Sample Size	775	707	775	750	775	750
Minimum	0	0	0	0	0	0
Maximum	0.88	1.1	1.46	0.48	0.6	0.06
Range	0.88	1.1	1.46	0.48	0.6	0.06
Mean	0.01455	0.01989	0.01267	0.00193	0.00148	8.00000E-5
Median	0	0	0	0	0	0
Variance	0.006	0.00891	0.00688	4.66885E-4	5.98441E-4	4.80000E-6
Std. Deviation	0.07745	0.0944	0.08294	0.02161	0.02446	0.00219
Coef. of Variation	5.32113	4.74685	6.54591	11.1763	16.48597	27.38613
Std. Error	0.00278	0.00355	0.00298	7.88995E-4	8.78739E-4	8.00000E-5
Skewness	7.38185	6.81154	11.56559	16.97885	21.42177	27.38613
Kurtosis	61.94708	54.77602	166.70103	340.04095	492.75746	750.0

Table B.41 - (Continued)

	July	August	September	October	November	December
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0	0	0
Maximum	0.6	1.38	0.99	2.2	0.68	1.32
Range	0.6	1.38	0.99	2.2	0.68	1.32
Mean	0.00303	0.00886	0.00592	0.0065	0.00608	0.0147
Median	0	0	0	0	0	0
Variance	0.0012	0.00672	0.00261	0.00772	0.0023	0.00834
Std. Deviation	0.0347	0.08195	0.05109	0.08785	0.04796	0.0913
Coef. of Variation	11.4449	9.24487	8.6307	13.50889	7.88828	6.21248
Std. Error	0.00125	0.00294	0.00187	0.00316	0.00175	0.00328
Skewness	14.31213	12.47297	12.92558	21.51789	10.91404	9.18377
Kurtosis	223.64368	173.35188	207.38507	514.77263	131.81059	99.17007

Table B.42 - Brawley-Calipatria precipitation statistics by month (1982-2004)

Month	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Freq 0	Percent
January	Prcp1	713	0.013	0.072	0.000	0.880	660	92.570
February	Prcp2	667	0.018	0.092	0.000	1.100	602	90.250
March	Prcp3	713	0.010	0.079	0.000	1.460	663	92.990
April	Prcp4	690	0.002	0.022	0.000	0.480	678	98.260
May	Prcp5	713	0.001	0.012	0.000	0.300	707	99.160
June	Prcp6	690	0.000	0.002	0.000	0.060	689	99.860
July	Prcp7	713	0.004	0.042	0.000	0.600	700	98.180
August	Prcp8	713	0.009	0.083	0.000	1.380	689	96.630
September	Prcp9	690	0.007	0.053	0.000	0.990	669	96.960
October	Prcp10	713	0.008	0.094	0.000	2.200	696	97.620
November	Prcp11	690	0.005	0.043	0.000	0.680	661	95.800
December	Prcp12	696	0.016	0.096	0.000	1.320	638	91.670

Table B.43 - Thermal-Indio (1980-2004) precipitation descriptive statistics: months

	January	**February**	**March**	**April**	**May**	**June**
Sample Size	775	707	775	750	775	750
Minimum	0	0	0	0	0	0
Maximum	2.27	1.15	1.22	0.32	0.43	0.14
Range	2.27	1.15	1.22	0.32	0.43	0.14
Mean	0.01916	0.02665	0.01588	0.00177	0.0011	3.20000E-4
Median	0	0	0	0	0	0
Variance	0.01366	0.01432	0.00703	2.78160E-4	2.84196E-4	3.70136E-5
Std. Deviation	0.11689	0.11966	0.08382	0.01668	0.01686	0.00608
Coef. of Variation	6.1002	4.49058	5.27686	9.40495	15.37063	19.01213
Std. Error	0.0042	0.0045	0.00301	6.08999E-4	6.05561E-4	2.22152E-4
Skewness	12.90076	6.1056	7.66131	13.66001	22.4081	20.49379
Kurtosis	211.14705	41.62057	75.4796	217.81789	550.3099	434.48576

Table B.43 - (Continued)

	July	August	September	October	November	December
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0	0	0
Maximum	1.43	2.18	1.91	0.74	1.34	1
Range	1.43	2.18	1.91	0.74	1.34	1
Mean	0.00493	0.00788	0.00832	0.00551	0.00771	0.00895
Median	0	0	0	0	0	0
Variance	0.00439	0.00743	0.00612	0.00204	0.00428	0.00364
Std. Deviation	0.06628	0.08621	0.0782	0.04513	0.06544	0.06037
Coef. of Variation	13.44757	10.93521	9.39921	8.19144	8.49127	6.74135
Std. Error	0.00238	0.0031	0.00286	0.00162	0.00239	0.00217
Skewness	17.40446	21.34941	20.08619	10.62941	14.23174	11.17089
Kurtosis	329.54633	524.18068	471.74708	130.88944	251.07925	150.56231

Table B.44 - Thermal-Indio (1980-2004) precipitation statistics by month (1980-2004)

Month	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Freq 0	Percent
January	Prcp1	775	0.019	0.117	0.000	2.270	691	89.160
February	Prcp2	707	0.027	0.120	0.000	1.150	628	88.830
March	Prcp3	775	0.016	0.084	0.000	1.220	703	90.710
April	Prcp4	750	0.002	0.017	0.000	0.320	730	97.330
May	Prcp5	775	0.001	0.017	0.000	0.430	763	98.450
June	Prcp6	750	0.000	0.006	0.000	0.140	747	99.600
July	Prcp7	775	0.005	0.066	0.000	1.430	749	96.650
August	Prcp8	775	0.008	0.086	0.000	2.180	748	96.520
September	Prcp9	750	0.008	0.078	0.000	1.910	703	93.730
October	Prcp10	775	0.006	0.045	0.000	0.740	746	96.260
November	Prcp11	750	0.008	0.065	0.000	1.340	719	95.870
December	Prcp12	775	0.009	0.060	0.000	1.000	720	92.900

Table B.45 - Brawley-Calipatria & Thermal-Indio averaged (1980-2004) precipitation descriptive statistics: months

	January	**February**	**March**	**April**	**May**	**June**
Sample Size	775	707	775	750	775	750
Minimum	0	0	0	0	0	0
Maximum	1.275	0.86	0.82	0.255	0.3	0.07
Range	1.275	0.86	0.82	0.255	0.3	0.07
Mean	0.01686	0.02327	0.01428	0.00185	0.00129	2.00000E-4
Median	0	0	0	0	0	0
Variance	0.00654	0.00744	0.0048	2.20125E-4	2.23591E-4	1.04406E-5
Std. Deviation	0.08087	0.08627	0.06927	0.01484	0.01495	0.00323
Coef. of Variation	4.79706	3.70766	4.85138	8.00537	11.58855	16.15595
Std. Error	0.0029	0.00324	0.00249	5.41757E-4	5.37127E-4	1.17986E-4
Skewness	8.86183	5.01832	7.21051	11.81258	15.73555	18.11677
Kurtosis	103.15852	29.56241	61.94415	165.87673	273.02086	349.53432

Table B.45 - (Continued)

	July	August	September	October	November	December
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0	0	0
Maximum	0.715	1.655	0.955	1.27	0.67	1.16
Range	0.715	1.655	0.955	1.27	0.67	1.16
Mean	0.00398	0.00837	0.00712	0.00601	0.00689	0.01183
Median	0	0	0	0	0	0
Variance	0.00169	0.00525	0.00231	0.00312	0.00198	0.00492
Std. Deviation	0.04106	0.07249	0.04805	0.05587	0.04455	0.07012
Coef. of Variation	10.31487	8.65634	6.74896	9.30158	6.46216	5.92935
Std. Error	0.00147	0.0026	0.00175	0.00201	0.00163	0.00252
Skewness	14.16249	17.16005	13.13424	16.98474	9.35998	10.52178
Kurtosis	218.37338	358.58642	222.8246	352.31476	104.12283	137.733

Table B.46 - Brawley-Calipatria & Thermal-Indio averaged precipitation statistics by month (1980-2004)

Month	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Freq 0	Percent
January	Prcp1	775	0.017	0.081	0.000	1.280	667	86.060
February	Prcp2	707	0.024	0.087	0.000	0.860	595	84.160
March	Prcp3	775	0.015	0.070	0.000	0.820	672	86.710
April	Prcp4	750	0.002	0.015	0.000	0.260	722	96.270
May	Prcp5	775	0.001	0.015	0.000	0.300	757	97.680
June	Prcp6	750	0.000	0.003	0.000	0.070	746	99.470
July	Prcp7	775	0.004	0.041	0.000	0.720	749	96.650
August	Prcp8	775	0.009	0.073	0.000	1.660	730	94.190
September	Prcp9	750	0.007	0.048	0.000	0.960	690	92.000
October	Prcp10	775	0.006	0.056	0.000	1.270	739	95.350
November	Prcp11	750	0.007	0.045	0.000	0.670	701	93.470
December	Prcp12	775	0.012	0.071	0.000	1.160	685	88.390

Table B.47 - Brawley-Calipatria (1982-2004) variables Eto descriptive statistics: months

	January	February	March	April	May	June
Sample Size	775	707	775	750	775	750
Minimum	0	0	0	0	0	0
Maximum	0.42	0.504	0.6615	0.7665	0.903	1.008
Range	0.42	0.504	0.6615	0.7665	0.903	1.008
Mean	0.12144	0.17244	0.24994	0.34826	0.4215	0.47808
Median	0.1155	0.168	0.2625	0.3675	0.4305	0.4935
Variance	0.00453	0.00818	0.01396	0.022	0.02884	0.03252
Std. Deviation	0.06727	0.09042	0.11816	0.14831	0.16983	0.18033
Coef. of Variation	0.55396	0.52434	0.47277	0.42586	0.40291	0.3772
Std. Error	0.00242	0.0034	0.00424	0.00542	0.0061	0.00658
Skewness	0.35372	0.07938	-0.29515	-0.75156	-0.86513	-1.11993
Kurtosis	0.76153	0.30342	0.41552	0.87418	1.33089	1.75176

Table B.47 - (Continued)

	July	**August**	**September**	**October**	**November**	**December**
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0	0	0
Maximum	1.0185	1.05	0.903	0.6825	0.588	0.441
Range	1.0185	1.05	0.903	0.6825	0.588	0.441
Mean	0.46331	0.4174	0.37239	0.2728	0.17016	0.11563
Median	0.4935	0.4515	0.3885	0.273	0.168	0.105
Variance	0.03104	0.02887	0.02355	0.01288	0.00685	0.004
Std. Deviation	0.17619	0.16992	0.15345	0.11351	0.08274	0.06326
Coef. of Variation	0.38029	0.4071	0.41208	0.4161	0.48626	0.54705
Std. Error	0.00633	0.0061	0.0056	0.00408	0.00302	0.00227
Skewness	-1.1489	-0.97603	-0.62386	-0.03909	0.4447	0.96622
Kurtosis	1.91199	1.25388	1.33371	0.75203	1.27589	2.19507

Table B.48 - Brawley-Calipatria (1982-2004) variables Eto statistics by month (1982-2004)

Month	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Freq <=0.21	Percent
January	Eto1	709	0.133	0.059	0.010	0.420	642	90.550
February	Eto2	667	0.188	0.078	0.011	0.504	456	68.370
March	Eto3	704	0.277	0.092	0.011	0.662	168	23.860
April	Eto4	683	0.385	0.105	0.053	0.767	29	4.250
May	Eto5	708	0.464	0.115	0.074	0.903	4	0.560
June	Eto6	690	0.519	0.116	0.168	1.008	2	0.290
July	Eto7	711	0.505	0.113	0.116	1.019	7	0.980
August	Eto8	709	0.455	0.117	0.032	1.050	19	2.680
September	Eto9	685	0.402	0.112	0.021	0.903	23	3.360
October	Eto10	713	0.283	0.099	0.021	0.683	177	24.820
November	Eto11	687	0.177	0.074	0.011	0.588	518	75.400
December	Eto12	695	0.120	0.059	0.011	0.378	643	92.520

Table B.49 - Thermal-Indio (1980-2004) evapotranspiration descriptive statistics: months

	January	February	March	April	May	June
Sample Size	775	707	775	750	775	750
Minimum	0	0	0	0	0	0
Maximum	0.32	0.294	0.4725	0.7035	0.5775	0.8715
Range	0.32	0.294	0.4725	0.7035	0.5775	0.8715
Mean	0.08794	0.12304	0.18099	0.25641	0.29673	0.31045
Median	0.09	0.126	0.19	0.27	0.31	0.33
Variance	0.00271	0.00292	0.00625	0.00986	0.01171	0.01962
Std. Deviation	0.05203	0.05405	0.07907	0.09932	0.10824	0.14008
Coef. of Variation	0.59159	0.43932	0.43685	0.38733	0.36476	0.45123
Std. Error	0.00187	0.00203	0.00284	0.00363	0.00389	0.00512
Skewness	0.94754	-0.2181	-0.43945	-0.78409	-1.32096	-0.59933
Kurtosis	2.75	0.38292	0.93829	2.5022	2.51599	1.63794

Table B.49 - (Continued)

	July	August	September	October	November	December
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0	0	0
Maximum	1.449	0.672	0.5985	0.4725	0.2625	0.24
Range	1.449	0.672	0.5985	0.4725	0.2625	0.24
Mean	0.29736	0.28004	0.23892	0.16481	0.10387	0.07352
Median	0.32	0.29	0.25	0.17	0.11	0.07
Variance	0.02048	0.01408	0.01	0.00533	0.00222	0.00139
Std. Deviation	0.14312	0.11866	0.1	0.07303	0.04716	0.03725
Coef. of Variation	0.48129	0.42373	0.41854	0.44311	0.45403	0.50672
Std. Error	0.00514	0.00426	0.00365	0.00262	0.00172	0.00134
Skewness	0.32885	-0.26628	-0.32832	-0.19274	-0.16085	0.43104
Kurtosis	6.22418	1.79694	1.86173	1.72164	0.63621	1.37583

Table B.50 - Thermal-Indio Eto statistics by month (1980-2004)

Month	**Variable**	**Obs.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**Freq <=0.21**	**Percent**
January	Eto1	713	0.096	0.047	0.000	0.320	694	97.340
February	Eto2	675	0.129	0.048	0.000	0.290	646	95.700
March	Eto3	715	0.196	0.062	0.000	0.470	462	64.620
April	Eto4	690	0.279	0.067	0.060	0.700	75	10.870
May	Eto5	713	0.322	0.066	0.000	0.580	18	2.520
June	Eto6	660	0.353	0.086	0.030	0.870	7	1.060
July	Eto7	688	0.335	0.102	0.000	1.450	37	5.380
August	Eto8	713	0.304	0.089	0.050	0.670	71	9.960
September	Eto9	690	0.260	0.074	0.020	0.600	166	24.060
October	Eto10	712	0.179	0.056	0.000	0.470	563	79.070
November	Eto11	696	0.112	0.039	0.000	0.260	687	98.710
December	Eto12	728	0.078	0.033	0.000	0.240	726	99.730

Table B.51 - Brawley-Calipatria & Thermal-Indio averaged (1980-2004) Eto descriptive statistics: months

	January	**February**	**March**	**April**	**May**	**June**
Sample Size	775	707	775	750	775	750
Minimum	0.01	0	0.02625	0.0525	0	0.2205
Maximum	0.3465	0.357	0.504	0.714	0.777	0.8715
Range	0.3365	0.357	0.47775	0.6615	0.777	0.651
Mean	0.11418	0.15803	0.23701	0.3348	0.39491	0.44812
Median	0.10825	0.155	0.2315	0.33	0.39025	0.43275
Variance	0.00206	0.003	0.00444	0.00576	0.0055	0.0078
Std. Deviation	0.04533	0.05476	0.06667	0.07592	0.07415	0.08832
Coef. of Variation	0.39704	0.34653	0.28128	0.22678	0.18776	0.1971
Std. Error	0.00163	0.00206	0.00239	0.00277	0.00266	0.00323
Skewness	0.86332	0.30236	0.25635	0.62503	0.25322	0.8761
Kurtosis	2.18218	0.55307	0.56841	2.58837	1.90793	1.65215

Table B.51 - (Continued)

	July	**August**	**September**	**October**	**November**	**December**
Sample Size	775	775	750	775	750	775
Minimum	0	0	0	0.04125	0	0.0105
Maximum	1.449	0.777	0.8085	0.609	0.588	0.294
Range	1.449	0.777	0.8085	0.56775	0.588	0.2835
Mean	0.43093	0.38595	0.3351	0.23732	0.14723	0.10099
Median	0.4215	0.3845	0.32913	0.231	0.14	0.093
Variance	0.01058	0.00833	0.00699	0.00487	0.00272	0.00172
Std. Deviation	0.10286	0.09129	0.08359	0.06977	0.05217	0.04146
Coef. of Variation	0.2387	0.23654	0.24946	0.29398	0.35435	0.41051
Std. Error	0.00369	0.00328	0.00305	0.00251	0.00191	0.00149
Skewness	1.69332	-0.1321	0.18351	0.71171	1.265	1.36748
Kurtosis	14.50988	2.40274	3.16429	1.68142	6.85883	3.18716

Table B.52 - Brawley-Calipatria & Thermal-Indio averaged Eto statistics by month (1980-2004)

Month	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Freq <=0.21	Percent
January	Eto1	775	0.114	0.046	0.010	0.350	753	97.160
February	Eto2	707	0.158	0.055	0.000	0.360	605	85.570
March	Eto3	775	0.237	0.067	0.030	0.500	283	36.520
April	Eto4	750	0.335	0.076	0.050	0.710	26	3.470
May	Eto5	775	0.395	0.074	0.000	0.780	4	0.520
June	Eto6	750	0.448	0.088	0.220	0.870	0	0.000
July	Eto7	773	0.432	0.101	0.000	1.450	6	0.780
August	Eto8	771	0.388	0.087	0.040	0.780	17	2.200
September	Eto9	745	0.337	0.079	0.020	0.810	24	3.220
October	Eto10	775	0.237	0.070	0.040	0.610	298	38.450
November	Eto11	748	0.148	0.052	0.020	0.590	679	90.780
December	Eto12	775	0.101	0.041	0.010	0.290	756	97.550

Table B.53 - Brawley-Calipatria (1982-2004) monthly historic frequency (percent) of subsequent precipitation events

CatEvent	0	1	2	3	4	5	6	7	Total
Month 1	660 (92.570)	31 (4.350)	13 (1.820)	4 (0.560)	2 (0.280)	1 (0.140)	1 (0.140)	1 (0.140)	713
Month 2	602 (90.250)	38 (5.700)	17 (2.550)	5 (0.750)	2 (0.300)	2 (0.300)	1 (0.150)	0	667
Month 3	663 (92.990)	34 (4.770)	13 (1.820)	3 (0.420)	0	0	0	0	713
Month 4	678 (98.260)	7 (1.010)	4 (0.580)	1 (0.140)	0	0	0	0	690
Month 5	707 (99.160)	5 (0.700)	1 (0.140)	0	0	0	0	0	713
Month 6	689 (99.860)	1 (0.140)	0	0	0	0	0	0	690
Month 7	700 (98.180)	10 (1.400)	3 (1.400)	0	0	0	0	0	713
Month 8	689 (96.630)	19 (2.660)	4 (0.560)	1 (0.140)	0	0	0	0	713
Month 9	669 (96.960)	16 (2.320)	5 (0.720)	0	0	0	0	0	690
Month 10	696 (97.620)	9 (1.260)	5 (0.700)	2 (0.280)	1 (0.140)	0	0	0	713
Month 11	661 (95.800)	18 (2.610)	9 (1.300)	1 (0.140)	1 (0.140)	0	0	0	690
Month 12	638 (91.67)	33 (4.74)	14 (2.01)	6 (0.86)	4 (0.57)	1 (0.14)	0	0	696

Table B.54 - Brawley-Calipatria (1982-2004) variables Month versus PrcpAmt (percent of PrcpAmt for individual months)

	PrcpAmt					
Month	**0**	**1**	**2**	**3**	**4**	**Total**
1	660	24 (45)	17 (32)	6 (11)	6 (11)	713
2	602	37 (57)	10 (15)	14 (22)	4 (6)	667
3	663	32 (64)	9 (18)	7 (14)	2 (4)	713
4	678	8 (67)	2 (17)	2 (17)	0	690
5	707	5 (83)	0	1 (17)	0	713
6	689	1 (1)	0	0	0	690
7	700	6 (46)	1 (8)	3 (23)	3 (23)	713
8	689	15 (63)	1 (4)	4 (17)	4 (17)	713
9	669	7 (33)	6 (29)	7 (33)	1 (5)	690
10	696	6 (35)	4 (24)	4 (24)	3 (18)	713
11	661	22 (76)	1 (3)	4 (14)	2 (7)	690
12	638	36 (62)	5 (9)	10 (17)	7 (12)	696
Total	8,052	199	56	62	32	8,401

Pearson chi2(44) = 243.9926   Pr = 0.000

Table B.55 - Brawley-Calipatria (1982-2004) variables Month versus CatEvent (percent of CatEvent for individual months)

Month	CatEvent 0	1	2	3	4	5	6	7	Total
1	660	31 (58)	13 (25)	4 (8)	2 (4)	1 (2)	1 (2)	1 (2)	713
2	602	38 (58)	17 (26)	5 (8)	2 (3)	2 (3)	1 (2)	0	667
3	663	34 (68)	13 (26)	3 (6)	0	0	0	0	713
4	678	7 (58)	4 (33)	1 (8)	0	0	0	0	690
5	707	5 (83)	1 (17)	0	0	0	0	0	713
6	689	1 (1)	0	0	0	0	0	0	690
7	700	10 (77)	3 (23)	0	0	0	0	0	713
8	689	19 (79)	4 (17)	1 (4)	0	0	0	0	713
9	669	16 (76)	5 (24)	0	0	0	0	0	690
10	696	9 (53)	5 (29)	2 (12)	1 (6)	0	0	0	713
11	661	18 (62)	9 (31)	1 (3)	1 (3)	0	0	0	690
12	638	33 (57)	14 (24)	6 (10)	4 (7)	1 (2)	0	0	696
Total	8,052	221	88	23	10	4	2	1	8,401

Pearson chi2(77) = 238.8089   Pr = 0.000

Table B.56 - Brawley-Calipatria (1982-2004) variables Month versus CatVol (percent of CatVol for individual months)

	CatVol					
Month	**0**	**1**	**2**	**3**	**4**	**Total**
1	660	31 (58)	13 (25)	1 (2)	8 (15)	713
2	602	38 (58)	14 (22)	1 (2)	12 (18)	667
3	663	34 (68)	9 (18)	2 (4)	5 (10)	713
4	678	7 (58)	0	1 (8)	4 (33)	690
5	707	5 (83)	1 (17)	0	0	713
6	689	1 (1)	0	0	0	690
7	700	10 (77)	3 (23)	0	0	713
8	689	19 (79)	2 (8)	0	3 (13)	713
9	669	16 (76)	3 (14)	0	2 (10)	690
10	696	9 (53)	5 (29)	0	3 (18)	713
11	661	18 (62)	5 (17)	2 (7)	4 (14)	690
12	638	35 (60)	17 (29)	0	6 (10)	696
Total	8,052	223	72	7	47	8,401

Pearson chi2(44) = 221.7690   Pr = 0.000

Table B.57 - Thermal-Indio (1980-2004) monthly historic frequency (percent) of subsequent precipitation events

CatEvent	0	1	2	3	4	5	6	7	8	9	Total
Month 1	691 (89.16)	55 (7.10)	19 (2.45)	7 (0.90)	2 (0.26)	1 (0.13)	0	0	0	0	775
Month 2	628 (88.83)	50 (7.07)	16 (2.26)	5 (0.71)	3 (0.42)	1 (0.14)	1 (0.14)	1 (0.14)	1 (0.14)	1 (0.14)	707
Month 3	703 (90.71)	43 (5.55)	17 (2.19)	4 (0.52)	3 (0.39)	2 (0.26)	1 (0.13)	1 (0.13)	1 (0.13)	0	775
Month 4	730 (97.33)	19 (2.53)	1 (0.13)	0	0	0	0	0	0	0	750
Month 5	763 (98.45)	12 (1.55)	0	0	0	0	0	0	0	0	775
Month 6	747 (99.60)	3 (0.40)	0	0	0	0	0	0	0	0	750
Month 7	749 (96.65)	18 (2.32)	5 (0.65)	3 (0.39)	0	0	0	0	0	0	775
Month 8	748 (96.52)	20 (2.58)	4 (0.52)	1 (0.13)	1 (0.13)	1 (0.13)	0	0	0	0	775
Month 9	703 (93.73)	30 (4.00)	9 (1.20)	5 (0.67)	2 (0.27)	1 (0.13)	0	0	0	0	750
Month 10	746 (96.26)	19 (2.45)	8 (1.03)	2 (0.26)	0	0	0	0	0	0	775
Month 11	719 (95.87)	24 (3.20)	6 (0.80)	1 (0.13)	0	0	0	0	0	0	750
Month 12	720 (92.90)	36 (4.65)	13 (1.68)	5 (0.65)	1 (0.13)	0	0	0	0	0	775

Table B.58 - Brawley-Calipatria & Thermal-Indio averaged (1980-2004) monthly historic frequency (percent) of subsequent precipitation events

CatEvent	0	1	2	3	4	5	6	7	8	9	10	Total
	667	52	29	12	6	3	2	1	1	1	1	775
Month 1	(86.06)	(6.71)	(3.74)	(1.55)	(0.77)	(0.39)	(0.26)	0.13)	(0.13)	(0.13)	(0.13)	
	595	54	31	11	7	3	2	2	1	1	0	707
Month 2	(84.16)	(7.64)	(4.38)	(1.56)	(0.99)	(0.42)	(0.28)	(0.28)	(0.14)	(0.14)		
	672	52	30	12	4	2	1	1	1	0	0	775
Month 3	(86.71)	(6.71)	(3.87)	(1.55)	(0.52)	(0.26)	(0.13)	(0.13)	(0.13)			
	722	18	6	2	2	0	0	0	0	0	0	750
Month 4	(96.27)	(2.40)	(0.80)	(0.27)	(0.27)							
	757	13	5	0	0	0	0	0	0	0	0	775
Month 5	(97.68)	(1.68)	(0.65)									
	746	4	0	0	0	0	0	0	0	0	0	750
Month 6	(99.47)	(0.53)										
	749	18	5	3	0	0	0	0	0	0	0	775
Month 7	(96.65)	(2.32)	(0.65)	(0.39)								
	730	34	7	2	1	1	0	0	0	0	0	775
Month 8	(94.19)	(4.39)	(0.90)	(0.26)	(0.13)	(0.13)						
	690	33	14	6	2	2	1	1	1	0	0	750
Month 9	(92.00)	(4.40)	(1.87)	(0.80)	(0.27)	(0.27)	(0.13)	(0.13)	(0.13)			
	739	20	10	4	2	0	0	0	0	0	0	775
Month 10	(95.35)	(2.58)	(1.29)	(0.52)	(0.26)							
	701	28	15	5	1	0	0	0	0	0	0	750
Month 11	(93.47)	(3.73)	(2.00)	(0.67)	(0.13)							
	685	40	22	14	7	4	1	1	1	0	0	775
Month 12	(88.39)	(5.16)	(2.84)	(1.81)	(0.90)	(0.52)	(0.13)	(0.13)	(0.13)			

Table B.59 - Brawley-Calipatria (1982-2004) variables Month versus EtoFirst (percent of EtoFirst for individual months)

	EtoFirst				
Month	**0**	**1**	**2**	**3**	**Total**
1	677	19 (59)	3 (9)	10 (31)	709
2	629	24 (63)	4 (11)	10 (26)	667
3	670	24 (71)	0	10 (29)	704
4	676	6 (86)	0	1 (14)	683
5	703	4 (80)	0	1 (20)	708
6	689	0	0	1 (100)	690
7	700	6 (60)	1 (10)	3 (30)	710
8	690	12 (63)	1 (5)	6 (32)	709
9	669	8 (50)	1 (6)	7 (44)	685
10	704	7 (78)	0	2 (22)	713
11	669	14 (78)	1 (6)	3 (17)	687
12	661	16 (47)	4 (12)	14 (41)	695
Total	8,137	140	15	68	8,360

Pearson chi2(33) = 122.7583   Pr = 0.000

Table B.60 - Brawley-Calipatria (1982-2004) variables Month versus Etolev2 (percent of Etolev2 for individual months)

	Etolev2				
Month	**0**	**1**	**2**	**3**	**Total**
1	680	5 (17)	1 (3)	24 (80)	710
2	629	8 (21)	1 (3)	29 (76)	667
3	669	9 (26)	1 (3)	24 (71)	703
4	676	2 (29)	0	5 (71)	683
5	704	2 (40)	0	3 (60)	709
6	689	0	0	1 (100)	690
7	701	4 (44)	0	5 (56)	710
8	691	9 (47)	0	10 (53)	710
9	669	10 (63)	0	6 (38)	685
10	704	2 (22)	0	7 (78)	713
11	669	3 (17)	1 (6)	14 (78)	687
12	661	5 (15)	2 (6)	26 (79)	694
Total	8,142	59	6	154	8,361

Table B.61 - Brawley-Calipatria (1982-2004) variables Month versus EtoOne (percent of EtoOne for individual months)

	EtoOne				
Month	**0**	**1**	**2**	**3**	**Total**
1	680	16 (53)	0	14 (47)	710
2	629	19 (50)	2 (5)	17 (45)	667
3	669	15 (47)	0	17 (53)	701
4	676	7 (100)	0	0	683
5	704	3 (60)	1 (20)	1 (20)	709
6	689	0	0	1 (100)	690
7	701	7 (70)	1 (10)	2 (20)	711
8	690	15 (79)	0	4 (21)	709
9	669	13 (81)	0	3 (19)	685
10	704	5 (56)	0	4 (44)	713
11	668	11 (61)	0	7 (39)	686
12	661	13 (39)	5 (15)	15 (45)	694
Total	8,140	124	9	85	8,358

Table B.62 - Brawley-Calipatria (1982-2004) variables Month versus EtoTwo (percent of EtoTwo for individual months)

	EtoTwo				
Month	**0**	**1**	**2**	**3**	**Total**
1	680	7 (23)	1 (3)	22 (73)	710
2	629	11 (29)	0	27 (71)	667
3	669	12 (36)	1 (3)	20 (61)	702
4	676	4 (57)	0	3 (43)	683
5	704	3 (60)	0	2 (40)	709
6	689	0	0	1 (100)	690
7	701	5 (50)	0	5 (50)	711
8	690	10 (53)	0	9 (47)	709
9	669	10 (63)	0	6 (38)	685
10	704	2 (22)	0	7 (78)	713
11	668	5 (29)	0	12 (71)	685
12	661	7 (21)	3 (9)	23 (70)	694
Total	8,140	76	5	137	8,358

Table B.63 - Brawley-Calipatria (1982-2004) variables Month versus EtoAmt (percent of EtoAmt for individual months)

	EtoAmt						
Month	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
1	262 (37)	380 (54)	62 (9)	4 (1)	1 (0)	0	709
2	81 (12)	375 (56)	170 (25)	37 (6)	3 (0)	1 (0)	667
3	19 (3)	149 (21)	347 (49)	131 (19)	48 (7)	10 (1)	704
4	5 (1)	24 (4)	147 (22)	265 (39)	153 (22)	89 (13)	683
5	1 (0)	3 (0)	45 (6)	205 (29)	228 (32)	226 (32)	708
6	0	2 (0)	18 (3)	93 (13)	214 (31)	363 (53)	690
7	0	7 (1)	27 (4)	91 (13)	227 (32)	359 (50)	711
8	5 (1)	14 (2)	58 (3)	141 (20)	252 (36)	239 (34)	709
9	3 (0)	20 (3)	118 (17)	260 (38)	172 (25)	112 (16)	685
10	16 (2)	161 (23)	331 (46)	135 (19)	47 (7)	23 (16)	713
11	110 (16)	408 (59)	137 (20)	29 (4)	2 (0)	1 (0)	687
12	358 (52)	285 (41)	48 (7)	4 (1)	0	0	695
Total	860	1,828	1,508	1,395	1,347	1,423	8,361

Table B.64 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{1,.........12}$) Month = Constant + X_1 Prcp*

						Prcp (X)
Month (Y)	**Mth. 1**	**Mth. 2**	**Mth. 3**	**Mth. 4**	**Mth. 5**	**Mth. 6**
(Y_1) Coefficient	Base	0.512	-0.375	**-6.368***	**-14.884***	**-67.972***
(Y_1) P-value	Base	0.341	0.567	0.004	0.003	0.012
(Y_2)Coefficient	-0.512	Base	-0.888	**-6.88***	**-15.396***	**-68.484***
(Y_2)P-value	0.341	Base	0.144	0.002	0.002	0.011
(Y_3) Coefficient	0.375	0.888	Base	**-5.993***	**-14.509***	**-67.597***
(Y_3) P-value	0.567	0.144	Base	0.007	0.003	0.012
(Y_4) Coefficient	**6.368***	**6.88***	**5.993***	Base	-8.516	**-61.604***
(Y_4) P-value	0.004	0.002	0.007	Base	0.111	0.022
(Y_5) Coefficient	**14.884***	**15.396***	**14.509***	8.516	Base	**-53.088***
(Y_5) P-value	0.003	0.002	0.003	0.111	Base	0.052
(Y_6) Coefficient	**67.972***	**68.484***	**67.597***	**61.604***	**53.088***	Base
(Y_6) P-value	0.012	0.011	0.012	0.022	0.052	Base
(Y_7) Coefficient	**2.806***	**3.318***	**2.43***	-3.563	**-12.078***	**-65.167***
(Y_7) P-value	0.019	0.005	0.046	0.141	0.016	0.016
(Y_8) Coefficient	0.758	1.270	0.383	**-5.61***	**-14.126***	**-67.214***
(Y_8) P-value	0.296	0.064	0.621	0.013	0.004	0.013
(Y_9) Coefficient	1.355	**1.867***	0.980	**-5.013***	**-13.529***	**-66.617***
(Y_9) P-value	0.115	0.024	0.275	0.029	0.007	0.013

Table B.64 - (Continued)

	Prcp (X)					
Month (Y)	**Mth. 7**	**Mth. 8**	**Mth. 9**	**Mth. 10**	**Mth. 11**	**Mh. 12**
(Y_1) Coefficient	**-2.806***	-0.758	-1.355	-0.979	**-1.988***	0.357
(Y_1) P-value	0.019	0.296	0.115	0.203	0.048	0.518
(Y_2)Coefficient	**-3.318***	-1.270	**-1.867***	**-1.492***	**-2.5***	-0.156
(Y_2)P-value	0.005	0.064	0.024	0.042	0.011	0.748
(Y_3) Coefficient	**-2.43***	-0.383	-0.980	-0.604	-1.613	0.732
(Y_3) P-value	0.046	0.621	0.275	0.458	0.120	0.236
(Y_4) Coefficient	3.563	**5.61***	**5.013***	**5.389***	4.380	**6.725***
(Y_4) P-value	0.141	0.013	0.029	0.017	0.061	0.002
(Y_5) Coefficient	**12.078***	**14.126***	**13.529***	**13.904***	**12.896***	**15.241***
(Y_5) P-value	0.016	0.004	0.007	0.005	0.010	0.002
(Y_6) Coefficient	**65.167***	**67.214***	**66.617***	**66.993***	**65.984***	**68.329***
(Y_6) P-value	0.016	0.013	0.013	0.013	0.014	0.011
(Y_7) Coefficient	Base	2.048	1.450	1.826	0.817	**3.162***
(Y_7) P-value	Base	0.102	0.275	0.153	0.565	0.007
(Y_8) Coefficient	-2.048	Base	-0.597	-0.221	-1.230	1.115
(Y_8) P-value	0.102	Base	0.528	0.799	0.254	0.108
(Y_9) Coefficient	-1.450	0.597	Base	0.376	-0.633	**1.712***
(Y_9) P-value	0.275	0.528	Base	0.701	0.588	0.040

Table B.64 - (Continued)

Prcp (X)						
Month (Y)	**Mth. 1**	**Mth. 2**	**Mth. 3**	**Mth. 4**	**Mth. 5**	**Mth. 6**
(Y_{10}) Coefficient	0.979	**1.492***	0.604	**-5.389***	**-13.904***	**-66.993***
(Y_{10}) P-value	0.203	0.042	0.458	0.017	0.005	0.013
(Y_{11}) Coefficient	**1.988***	**2.5***	1.613	-4.380	**-12.896***	**-65.984***
(Y_{11}) P-value	0.048	0.011	0.120	0.061	0.010	0.014
(Y_{12}) Coefficient	-0.357	0.156	-0.732	**-6.725***	**-15.241***	**-68.329***
(Y_{12}) P-value	0.518	0.748	0.236	0.002	0.002	0.011

Table B.64 - (Continued)

Prcp (X)						
Month (Y)	**Mth. 7**	**Mth. 8**	**Mth. 9**	**Mth. 10**	**Mth. 11**	**Mth. 12**
(Y_{10}) Coefficient	-1.826	0.221	-0.376	Base	-1.009	1.336
(Y_{10}) P-value	0.153	0.799	0.701	Base	0.362	0.071
(Y_{11}) Coefficient	-0.817	1.230	0.633	1.009	Base	**2.345***
(Y_{11}) P-value	0.565	0.254	0.588	0.362	Base	0.017
(Y_{12}) Coefficient	**-3.162***	-1.115	**-1.712***	-1.336	**-2.345***	Base
(Y_{12}) P-value	0.007	0.108	0.040	0.071	0.017	Base

Table B.65 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{1,\ldots\ldots\ldots12}$) Month = Constant + X_1 Eto*

	Eto (X)					
Month (Y)	**Mth. 1**	**Mth. 2**	**Mth. 3**	**Mth. 4**	**Mth. 5**	**Mth. 6**
(Y_1) Coefficient	Base	**11.961***	**23.867***	**34.401***	**41.172***	**45.156***
(Y_1) P-value	Base	0.000	0.000	0.000	0.000	0.000
(Y_2) Coefficient	**-11.961***	Base	**11.905***	**22.439***	**29.21***	**33.195***
(Y_2) P-value	0.000	Base	0.000	0.000	0.000	0.000
(Y_3) Coefficient	**-23.867***	**-11.905***	Base	**10.534***	**17.305***	**21.29***
(Y_3) P-value	0.000	0.000	Base	0.000	0.000	0.000
(Y_4) Coefficient	**-34.401***	**-22.439***	**-10.534***	Base	**6.771***	**10.755***
(Y_4) P-value	0.000	0.000	0.000	Base	0.000	0.000
(Y_5) Coefficient	**-41.172***	**-29.21***	**-17.305***	**-6.771***	Base	**3.984***
(Y_5) P-value	0.000	0.000	0.000	0.000	Base	0.000
(Y_6) Coefficient	**-45.156***	**-33.195***	**-21.29***	**-10.755***	**-3.984***	Base
(Y_6) P-value	0.000	0.000	0.000	0.000	0.000	Base
(Y_7) Coefficient	**-44.187***	**-32.226***	**-20.321***	**-9.786***	**-3.015***	**0.969***
(Y_7) P-value	0.000	0.000	0.000	0.000	0.000	0.028
(Y_8) Coefficient	**-40.459***	**-28.498***	**-16.593***	**-6.059***	0.712	**4.697***
(Y_8) P-value	0.000	0.000	0.000	0.000	0.135	0.000
(Y_9) Coefficient	**-35.921***	**-23.96***	**-12.055***	**-1.521***	**5.25***	**9.235***

Table B.65 - (Continued)

	Eto (X)					
Month (Y)	**Mth. 7**	**Mth. 8**	**Mth. 9**	**Mth. 10**	**Mth. 11**	**Mth. 12**
(Y_1) Coefficient	**44.187***	**40.459***	**35.921***	**24.421***	**9.921***	**-3.741***
(Y_1) P-value	0.000	0.000	0.000	0.000	0.000	0.000
(Y_2) Coefficient	**32.226***	**28.498***	**23.96***	**12.46***	**-2.04***	**-15.702***
(Y_2) P-value	0.000	0.000	0.000	0.000	0.005	0.000
(Y_3) Coefficient	**20.321***	**16.593***	**12.055***	0.555	**-13.945***	**-27.607***
(Y_3) P-value	0.000	0.000	0.000	0.315	0.000	0.000
(Y_4) Coefficient	**9.786***	**6.059***	**1.521***	**-9.979***	**-24.479***	**-38.141***
(Y_4) P-value	0.000	0.000	0.003	0.000	0.000	0.000
(Y_5) Coefficient	**3.015***	-0.712	**-5.25***	**-16.75***	**-31.25***	**-44.912***
(Y_5) P-value	0.000	0.135	0.000	0.000	0.000	0.000
(Y_6) Coefficient	**-0.969***	**-4.697***	**-9.235***	**-20.735***	**-35.235***	**-48.897***
(Y_6) P-value	0.028	0.000	0.000	0.000	0.000	0.000
(Y_7) Coefficient	Base	**-3.728***	**-8.266***	**-19.766***	**-34.266***	**-47.928***
(Y_7) P-value	Base	0.000	0.000	0.000	0.000	0.000
(Y_8) Coefficient	**3.728***	Base	**-4.538***	**-16.038***	**-30.538***	**-44.2***
(Y_8) P-value	0.000	Base	0.000	0.000	0.000	0.000
(Y_9) Coefficient	**8.266***	**4.538***	Base	**-11.5***	**-26***	**-39.662***

Table B.65 - (Continued)

	Eto (X)					
Month (Y)	**Mth. 1**	**Mth. 2**	**Mth. 3**	**Mth. 4**	**Mth. 5**	**Mth. 6**
(Y_9) P-value	0	0	0	0.003	0	0
(Y_{10}) Coefficient	**-24.421***	**-12.46***	-0.555	**9.979***	**16.75***	**20.735***
(Y_{10}) P-value	0	0	0.315	0	0	0
(Y_{11}) Coefficient	**-9.921***	**2.04***	**13.945***	**24.479***	**31.25***	**35.235***
(Y_{11}) P-value	0	0.005	0	0	0	0
(Y_{12}) Coefficient	**3.741***	**15.702***	**27.607***	**38.141***	**44.912***	**48.897***
(Y_{12}) P-value	0	0	0	0	0	0

Table B.65 - (Continued)

	Eto (X)					
Month (Y)	**Mth. 7**	**Mth. 8**	**Mth. 9**	**Mth. 10**	**Mth. 11**	**Mth. 12**
(Y_9) P-value	0	0	Base	0	0	0
(Y_{10}) Coefficient	**19.766***	**16.038***	**11.5***	Base	**-14.5***	**-28.162***
(Y_{10}) P-value	0	0	0	Base	0	0
(Y_{11}) Coefficient	**34.266***	**30.538***	**26***	**14.5***	Base	**-13.662***
(Y_{11}) P-value	0	0	0	0	Base	0
(Y_{12}) Coefficient	**47.928***	**44.2***	**39.662***	**28.162***	**13.662***	Base
(Y_{12}) P-value	0	0	0	0	0	Base

Table B.66 - Brawley-Calipatria (1982-2004) variables CatEvent versus PrcpAmt (percent of CatEvent levels for PrcpAmt volumes & *percent of PrcpAmt volumes for individual CatEvent levels)

	PrcpAmt					
CatEvent	**0**	**1**	**2**	**3**	**4**	**Total**
0	8,052	0	0	0	0	8,052
1	0	125 (63, 57*)	37 (66, 17*)	39 (63, 18*)	20 (63, 9*)	221
2	0	49 (25, 56*)	14 (25, 16*)	15 (24, 17*)	10 (31, 11*)	88
3	0	13 (7, 57*)	4 (7, 17*)	6 (10, 26*)	0	23
4	0	7 (4, 70*)	1 (2, 10*)	1 (2, 10*)	1 (3, 10*)	10
5	0	2 (1, 50*)	0	1 (2, 25*)	1 (3, 25*)	4
6	0	2 (1, 100*)	0	0	0	2
7	0	1 (1, 100*)	0	0	0	1
Total	8,052	199	56	62	32	8,401

Pearson chi2(28) = 8.6e+03 Pr = 0.000

Table B.67 - Brawley-Calipatria (1982-2004) variables CatEvent versus CatVol (percent of CatVol for individual CatEvent levels)

	CatVol					
CatEvent	**0**	**1**	**2**	**3**	**4**	**Total**
0	8,052	0	0	0	0	8,052
1	0	221 (100)	0	0	0	221
2	0	0	48 (55)	6 (7)	34 (39)	88
3	0	0	14 (61)	1 (4)	8 (35)	23
4	0	1 (10)	6 (60)	0	3 (30)	10
5	0	1 (25)	1 (25)	0	2 (50)	4
6	0	0	2 (100)	0	0	2
7	0	0	1 (100)	0	0	1
Total	8,052	223	72	7	47	8,401

Pearson chi2(28) = 1.7e+04 Pr = 0.000

Table B.68 - Number (percent) of precipitation events (none versus single and single versus second day) and corresponding volumes

	0	**< 0.1**	**< 0.2**	**< 0.3**	**< 0.4**	**< 0.5**	**≥ 0.5**	**Total**
0	8,339 (96.3)	185 (2.1)	55 (0.6)	25 (0.3)	18 (0.2)	15 (0.2)	18 (0.2)	8,655
< 0.1	195 (71.7)	53 (19.5)	7 (2.6)	8 (2.9)	3 (1.1)	3 (1.1)	3 (1.1)	272
< 0.2	47 (65.3)	11 (15.3)	3 (4.2)	4 (5.6)	3 (4.2)	1 (1.4)	3 (4.2)	72
< 0.3	27 (57.4)	8 (17.0)	2 (4.3)	3 (6.4)	2 (4.3)	0	5 (10.6)	47
< 0.4	16 (55.2)	4 (13.8)	2 (6.9)	3 (10.3)	2 (6.9)	1 (3.4)	1 (3.4)	29
< 0.5	11 (52.4)	5 (23.8)	1 (4.8)	1 (4.8)	0	1 (4.8)	2 (9.5)	21
≥ 0.5	21 (61.8)	6 (17.6)	2 (5.9)	3 (8.8)	1 (2.9)	0	1 (2.9)	36

Table B.69 - Brawley-Calipatria (1982-2004) variables CatEvent versus EtoFirst (percent of EtoFirst for individual CatEvents)

	EtoFirst				
CatEvent	**0**	**1**	**2**	**3**	**Total**
0	8,017 (100)	0	0	0	8,017
1	0	136 (62)	15 (7)	67 (31)	218
2	85 (100)	0	0	0	85
3	23 (100)	0	0	0	23
4	10 (100)	0	0	0	10
5	7 (100)	0	0	0	7
Total	8,142	136	15	67	8,360

Table B.70 - Brawley-Calipatria (1982-2004) variables CatEvent versus Etolev2 (percent of Etolev2 for individual CatEvents)

	Etolev2				
CatEvent	**0**	**1**	**2**	**3**	**Total**
0	8,007	0	0	0	8,007
1	86 (39)	46 (21)	4 (2)	82 (38)	218
2	23 (26)	11 (13)	2 (2)	51 (59)	87
3	10 (43)	1 (4)	0	12 (52)	23
4	4 (40)	1 (10)	0	5 (50)	10
5	2 (50)	0	0	2 (50)	4
6	1 (50)	0	0	1 (50)	2
7	0	0	0	1 (100)	1
Total	8,133	59	6	154	8,352

Table B.71 - Brawley-Calipatria (1982-2004) variables CatEvent versus EtoOne (percent of EtoOne for individual CatEvents)

	EtoOne				
CatEvent	**0**	**1**	**2**	**3**	**Total**
0	8,005	0	0	0	8,005
1	86 (40)	73 (34)	6 (3)	52 (24)	217
2	23 (26)	40 (45)	1 (1)	24 (27)	88
3	10 (45)	6 (27)	1 (5)	5 (23)	22
4	4 (40)	3 (30)	1 (10)	2 (20)	10
5	2 (50)	0	0	2 (50)	4
6	1 (50)	1 (50)	0	0	2
7	0	1 (100)	0	0	1
Total	8,131	124	9	85	8,349

Table B.72 - Brawley-Calipatria (1982-2004) variables CatEvent versus EtoTwo (percent of EtoTwo for individual CatEvents)

	EtoTwo				
CatEvent	**0**	**1**	**2**	**3**	**Total**
0	8,006	0	0	0	8,006
1	85 (39)	47 (22)	4 (2)	81 (37)	217
2	23 (27)	22 (26)	1 (1)	40 (47)	86
3	10 (43)	5 (22)	0	8 (35)	23
4	4 (40)	0	0	6 (60)	10
5	2 (50)	1 (25)	0	1 (25)	4
6	1 (50)	1 (50)	0	0	2
7	0	0	0	1 (100)	1
Total	8,131	76	5	137	8,349

Table B.73 - Brawley-Calipatria (1982-2004) variables CatEvent versus EtoAmt (percent of EtoAmt for individual CatEvents)

	EtoAmt						
CatEvent	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
0	713 (9)	1,728 (22)	1,462 (18)	1,368 (17)	1,336 (17)	1,411 (18)	8,018
1	78 (36)	60 (28)	37 (17)	22 (10)	10 (5)	11 (5)	218
2	43 (51)	28 (33)	7 (8)	5 (6)	1 (1)	1 (1)	85
3	15 (65)	6 (26)	2 (9)	0	0	0	23
4	7 (70)	3 (30)	0	0	0	0	10
5	3 (75)	1 (25)	0	0	0	0	4
6	0	2 (100)	0	0	0	0	2
7	1 (100)	0	0	0	0	0	1
Total	860	1,828	1,508	1,395	1,347	1,423	8,361

Table B.74 - Brawley-Calipatria (1982-2004) variables PrcpAmt versus EtoFirst (percent of EtoFirst for individual PrcpAmt)

	EtoFirst				
PrcpAmt	**0**	**1**	**2**	**3**	**Total**
0	8,017 (1)	0	0	0	8,017
1	73 (37)	82 (42)	4 (2)	37 (19)	196
2	18 (33)	23 (43)	3 (6)	10 (19)	54
3	23 (37)	22 (35)	7 (11)	10 (16)	62
4	11 (35)	9 (29)	1 (3)	10 (32)	31
Total	8,142	136	15	67	8,360

Table B.75 - Brawley-Calipatria (1982-2004) variables PrcpAmt versus Etolev2 (percent of Etolev2 for individual PrcpAmt)

	Etolev2				
PrcpAmt	**0**	**1**	**2**	**3**	**Total**
0	8,007	0	0	0	8,007
1	61 (31)	33 (17)	5 (3)	98 (50)	197
2	20 (36)	7 (13)	0	28 (51)	55
3	29 (47)	14 (23)	0	19 (31)	62
4	16 (52)	5 (16)	1 (3)	9 (29)	31
Total	8,133	59	6	154	8,352

Table B.76 - Brawley-Calipatria (1982-2004) variables PrcpAmt versus EtoOne (percent of EtoOne for individual PrcpAmt)

	EtoOne				
PrcpAmt	**0**	**1**	**2**	**3**	**Total**
0	8,005	0	0	0	8,005
1	61 (31)	75 (38)	7 (4)	52 (27)	195
2	20 (36)	18 (32)	1 (2)	17 (27)	56
3	29 (47)	21 (34)	1 (2)	11 (18)	62
4	16 (52)	10 (32)	0	5 (16)	31
Total	8,131	124	9	85	8,349

Table B.77 - Brawley-Calipatria (1982-2004) variables PrcpAmt versus EtoTwo (percent of EtoTwo for individual PrcpAmt)

	EtoTwo				
PrcpAmt	**0**	**1**	**2**	**3**	**Total**
0	8,006	0	0	0	8,006
1	60 (31)	40 (21)	5 (3)	90 (46)	195
2	20 (36)	12 (22)	0	23 (42)	55
3	29 (47)	17 (27)	0	16 (26)	62
4	16 (52)	7 (23)	0	8 (26)	31
Total	8,131	76	5	137	8,349

Table B.78 - Brawley-Calipatria (1982-2004) variables PrcpAmt versus EtoAmt (percent of EtoAmt for individual PrcpAmt)

	EtoAmt						
PrcpAmt	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
0	713 (9)	1,728 (22)	1,462 (18)	1,368 (17)	1,336 (17)	1,411 (18)	8,018
1	76 (39)	66 (34)	30 (15)	15 (8)	8 (4)	1 (1)	196
2	26 (48)	14 (26)	10 (19)	3 (6)	0	1 (2)	54
3	30 (48)	14 (23)	4 (6)	7 (11)	1 (2)	6 (10)	62
4	15 (48)	6 (19)	2 (6)	2 (6)	2 (6)	4 (13)	31
Total	860	1,828	1,508	1,395	1,347	1,423	8,361

Table B.79 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,\ldots4}$) PrcpAmt = Constant + X_1 Eto*

```
Iteration 0:   log likelihood =  -1821.362
Iteration 1:   log likelihood = -1671.3706
Iteration 2:   log likelihood = -1633.8945
Iteration 3:   log likelihood = -1630.1742
Iteration 4:   log likelihood = -1630.0637
Iteration 5:   log likelihood = -1630.0635

Multinomial logistic regression                   Number of obs   =       8361
                                                  LR chi2(4)      =     382.60
                                                  Prob > chi2     =     0.0000
Log likelihood = -1630.0635                       Pseudo R2       =     0.1050

------------------------------------------------------------------------------
     PrcpAmt |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |  -8.240187   .6762675   -12.18   0.000    -9.565647   -6.914727
       _cons |  -1.760036   .1359075   -12.95   0.000     -2.02641   -1.493662
-------------+----------------------------------------------------------------
2            |
         Eto |   -10.8436   1.519688    -7.14   0.000    -13.82214   -7.865068
       _cons |  -2.652145   .2554169   -10.38   0.000    -3.152753   -2.151537
-------------+----------------------------------------------------------------
3            |
         Eto |  -7.452625    1.12287    -6.64   0.000    -9.653411    -5.25184
       _cons |  -3.045406   .2359862   -12.91   0.000     -3.50793   -2.582881
-------------+----------------------------------------------------------------
4            |
         Eto |  -5.566598   1.389117    -4.01   0.000    -8.289217   -2.843979
       _cons |  -4.094809   .3356697   -12.20   0.000     -4.75271   -3.436909
------------------------------------------------------------------------------
(PrcpAmt==0 is the base outcome)
```

Table B.80 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,\ldots,5}$) CatEvent = Constant + X_1 Eto*

```
Iteration 0:   log likelihood = -1773.4046
Iteration 1:   log likelihood = -1620.8823
Iteration 2:   log likelihood =  -1568.892
Iteration 3:   log likelihood = -1556.3347
Iteration 4:   log likelihood = -1553.6474
Iteration 5:   log likelihood = -1553.4491
Iteration 6:   log likelihood = -1553.4474
Iteration 7:   log likelihood = -1553.4474

Multinomial logistic regression                   Number of obs   =       8361
                                                  LR chi2(5)      =     439.91
                                                  Prob > chi2     =     0.0000
Log likelihood = -1553.4474                       Pseudo R2       =     0.1240

------------------------------------------------------------------------------
    CatEvent |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |   -5.99247   .5484252   -10.93   0.000    -7.067363   -4.917576
       _cons |  -2.057489     .12979   -15.85   0.000    -2.311873   -1.803105
-------------+----------------------------------------------------------------
2            |
         Eto |   -12.6651   1.367864    -9.26   0.000    -15.34606   -9.984134
       _cons |  -1.947836   .2095657    -9.29   0.000    -2.358577   -1.537095
-------------+----------------------------------------------------------------
3            |
         Eto |  -21.35504   3.751404    -5.69   0.000    -28.70766   -14.00243
       _cons |  -2.326591   .4007276    -5.81   0.000    -3.112002   -1.541179
-------------+----------------------------------------------------------------
4            |
         Eto |  -24.47995   6.134474    -3.99   0.000     -36.5033   -12.45661
       _cons |  -2.893033   .5917953    -4.89   0.000    -4.052931   -1.733136
-------------+----------------------------------------------------------------
5            |
         Eto |  -25.15178   7.434091    -3.38   0.001    -39.72233   -10.58123
       _cons |  -3.195991   .7020308    -4.55   0.000    -4.571946   -1.820036
------------------------------------------------------------------------------
(CatEvent==0 is the base outcome)
```

Table B.81 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,1}$) RainEvent = Constant + X_1 Eto*

```
Iteration 0:   log likelihood =  -1431.272
Iteration 1:   log likelihood = -1281.9494
Iteration 2:   log likelihood = -1246.4963
Iteration 3:   log likelihood = -1243.5628
Iteration 4:   log likelihood = -1243.5187
Iteration 5:   log likelihood = -1243.5187

Logistic regression                               Number of obs   =       8361
                                                  LR chi2(1)      =     375.51
                                                  Prob > chi2     =     0.0000
Log likelihood = -1243.5187                       Pseudo R2       =     0.1312

------------------------------------------------------------------------------
   RainEvent |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         Eto |  -8.134497   .5139508   -15.83   0.000    -9.141822   -7.127172
       _cons |  -1.218392   .1051522   -11.59   0.000    -1.424487   -1.012297
------------------------------------------------------------------------------
```

Table B.82 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,\ldots 4}$) CatVol = Constant + X_1 Eto*

```
Iteration 0:   log likelihood = -1759.8819
Iteration 1:   log likelihood = -1607.1371
Iteration 2:   log likelihood = -1556.1501
Iteration 3:   log likelihood =  -1544.944
Iteration 4:   log likelihood =  -1543.308
Iteration 5:   log likelihood = -1543.2638
Iteration 6:   log likelihood = -1543.2638

Multinomial logistic regression                   Number of obs   =       8361
                                                  LR chi2(4)      =     433.24
                                                  Prob > chi2     =     0.0000
Log likelihood = -1543.2638                       Pseudo R2       =     0.1231

------------------------------------------------------------------------------
      CatVol |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |  -6.075485   .5489672   -11.07   0.000    -7.151441   -4.999529
       _cons |  -2.032207   .1291231   -15.74   0.000    -2.285283    -1.77913
-------------+----------------------------------------------------------------
2            |
         Eto |  -15.83491   1.776181    -8.92   0.000    -19.31616   -12.35366
       _cons |  -1.765618   .2343112    -7.54   0.000    -2.224859   -1.306376
-------------+----------------------------------------------------------------
3            |
         Eto |  -5.297956   2.873047    -1.84   0.065    -10.92902    .3331119
       _cons |  -5.636979    .708672    -7.95   0.000    -7.025951   -4.248007
-------------+----------------------------------------------------------------
4            |
         Eto |  -16.13412   2.208209    -7.31   0.000    -20.46213   -11.80611
       _cons |  -2.152538   .2864451    -7.51   0.000     -2.71396   -1.591116
------------------------------------------------------------------------------
(CatVol==0 is the base outcome)
```

Table B.83 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,..3}$) EtoFirst = Constant + X_1 PrcpAmt*

```
Iteration 0:   log likelihood = -1214.5824
Iteration 1:   log likelihood =  -803.6483
Iteration 2:   log likelihood = -709.54587
Iteration 3:   log likelihood = -701.52156
Iteration 4:   log likelihood = -701.28569
Iteration 5:   log likelihood = -701.28454

Multinomial logistic regression                   Number of obs   =       8360
                                                  LR chi2(3)      =    1026.60
                                                  Prob > chi2     =     0.0000
Log likelihood = -701.28454                       Pseudo R2       =     0.4226

------------------------------------------------------------------------------
    EtoFirst |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
     PrcpAmt |   2.737393   .1339395    20.44   0.000     2.474877     2.99991
       _cons |  -5.126154   .1374647   -37.29   0.000     -5.39558   -4.856728
-------------+----------------------------------------------------------------
2            |
     PrcpAmt |   3.030397   .2256211    13.43   0.000     2.588187    3.472606
       _cons |  -7.955184     .50781   -15.67   0.000    -8.950473   -6.959895
-------------+----------------------------------------------------------------
3            |
     PrcpAmt |   2.812378   .1481942    18.98   0.000     2.521923    3.102833
       _cons |  -5.983403   .2035242   -29.40   0.000    -6.382303   -5.584503
------------------------------------------------------------------------------
(EtoFirst==0 is the base outcome)
```

Table B.84 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,\ldots4}$) EtoFirst = Constant + X_1 Eto*

```
Iteration 0:   log likelihood =  -1193.481
Iteration 1:   log likelihood = -1124.2488
Iteration 2:   log likelihood = -1107.3273
Iteration 3:   log likelihood = -1105.8839
Iteration 4:   log likelihood = -1105.8599
Iteration 5:   log likelihood = -1105.8599

Multinomial logistic regression                   Number of obs   =       8360
                                                  LR chi2(3)      =     175.24
                                                  Prob > chi2     =     0.0000
Log likelihood = -1105.8599                       Pseudo R2       =     0.0734
```

EtoFirst	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
Eto	-8.119001	.8063174	-10.07	0.000	-9.699354	-6.538648
_cons	-2.188732	.160238	-13.66	0.000	-2.502793	-1.874672
2						
Eto	-7.99246	2.379357	-3.36	0.001	-12.65591	-3.329006
_cons	-4.414236	.4724594	-9.34	0.000	-5.34024	-3.488233
3						
Eto	-2.180311	.7772565	-2.81	0.005	-3.703706	-.6569162
_cons	-4.147679	.2436327	-17.02	0.000	-4.62519	-3.670168

(EtoFirst==0 is the base outcome)

Table B.85 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results *(Logit $Y_{0..3}$) Etolev2 = Constant + X_1 PrcpAmt + X_2 CatEvent*

```
Iteration 0:   log likelihood = -1166.7135
Iteration 1:   log likelihood = -801.00102
Iteration 2:   log likelihood = -671.24449
Iteration 3:   log likelihood = -594.13027
Iteration 4:   log likelihood = -590.27014
Iteration 5:   log likelihood = -590.15828
Iteration 6:   log likelihood = -590.15786

Multinomial logistic regression                   Number of obs   =       8352
                                                  LR chi2(6)      =    1153.11
                                                  Prob > chi2     =     0.0000
Log likelihood = -590.15786                       Pseudo R2       =     0.4942

------------------------------------------------------------------------------
     Etolev2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
     PrcpAmt |   1.125933   .1345696     8.37   0.000     .8621809    1.389684
    CatEvent |   2.166863   .2068983    10.47   0.000      1.76135    2.572377
       _cons |  -6.344241   .2431044   -26.10   0.000    -6.820717   -5.867765
-------------+----------------------------------------------------------------
2            |
     PrcpAmt |   .8969752   .3450204     2.60   0.009     .2207477    1.573203
    CatEvent |   2.331596   .4130419     5.64   0.000     1.522049    3.141143
       _cons |  -8.462189   .6927181   -12.22   0.000    -9.819891   -7.104486
-------------+----------------------------------------------------------------
3            |
     PrcpAmt |   .8834243   .1168865     7.56   0.000     .6543309    1.112518
    CatEvent |   2.571995   .1782829    14.43   0.000     2.222567    2.921423
       _cons |  -5.557485   .1695077   -32.79   0.000    -5.889714   -5.225256
------------------------------------------------------------------------------
(Etolev2==0 is the base outcome)
```

Table B.86 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results *(Logit $Y_{0..3}$) Etolev2 = Constant + X_1Eto*

```
Iteration 0:   log likelihood = -1161.9486
Iteration 1:   log likelihood =  -1065.923
Iteration 2:   log likelihood = -1028.2429
Iteration 3:   log likelihood =    -1021.4
Iteration 4:   log likelihood = -1020.8924
Iteration 5:   log likelihood = -1020.8888

Multinomial logistic regression                   Number of obs   =       8322
                                                  LR chi2(3)      =     282.12
                                                  Prob > chi2     =     0.0000
Log likelihood = -1020.8888                       Pseudo R2       =     0.1214

------------------------------------------------------------------------------
     Etolev2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |  -.6228203    .779018    -0.80   0.424    -2.149667    .9040268
       _cons |  -4.722465   .2763278   -17.09   0.000    -5.264057   -4.180872
-------------+----------------------------------------------------------------
2            |
         Eto |  -10.96812   4.608614    -2.38   0.017    -20.00084   -1.935407
       _cons |  -4.867552   .7574302    -6.43   0.000    -6.352088   -3.383016
-------------+----------------------------------------------------------------
3            |
         Eto |  -12.01257   .9956708   -12.06   0.000    -13.96405    -10.0611
       _cons |  -1.488583   .1570307    -9.48   0.000    -1.796358   -1.180809
------------------------------------------------------------------------------
(Etolev2==0 is the base outcome)
```

Table B.87 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results *(Logit $Y_{0,..3}$) Etolev2 = Constant + X_1 PrcpAmt + X_2 CatVol + X_3 CatEvent + X_4 Month*

```
Iteration 0:   log likelihood = -1166.7135
Iteration 1:   log likelihood = -827.48306
Iteration 2:   log likelihood = -795.07159
Iteration 3:   log likelihood = -687.35732
Iteration 4:   log likelihood = -610.08866
Iteration 5:   log likelihood = -589.60961
Iteration 6:   log likelihood = -588.92691
Iteration 7:   log likelihood = -588.92525
Iteration 8:   log likelihood = -588.92525

Multinomial logistic regression                   Number of obs   =       8352
                                                  LR chi2(12)     =    1155.58
                                                  Prob > chi2     =     0.0000
Log likelihood = -588.92525                       Pseudo R2       =     0.4952

------------------------------------------------------------------------------
     Etolev2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
     PrcpAmt |    1.15828   .1367802     8.47   0.000     .8901953    1.426364
      CatVol |  -.1912227   .3210991    -0.60   0.551    -.8205654    .4381199
    CatEvent |    2.33322   .4143528     5.63   0.000     1.521103    3.145336
       Month |   -.008825   .0374269    -0.24   0.814    -.0821804    .0645304
       _cons |  -6.287947   .3382684   -18.59   0.000    -6.950941   -5.624953
-------------+----------------------------------------------------------------
2            |
     PrcpAmt |   .8035734   .3880558     2.07   0.038      .042998    1.564149
      CatVol |   .2658799   .5503851     0.48   0.629     -.812855    1.344615
    CatEvent |   2.121328   .7032857     3.02   0.003      .742913    3.499742
       Month |   .0347121   .1021053     0.34   0.734    -.1654106    .2348348
       _cons |  -8.694198   .9875528    -8.80   0.000    -10.62977    -6.75863
-------------+----------------------------------------------------------------
3            |
     PrcpAmt |   .8660501   .1193494     7.26   0.000     .6321297    1.099971
      CatVol |   .0160481   .2835617     0.06   0.955    -.5397227    .5718189
    CatEvent |   2.566497   .3837067     6.69   0.000     1.814445    3.318548
       Month |  -.0241865   .0290999    -0.83   0.406    -.0812212    .0328483
       _cons |   -5.40587   .2462442   -21.95   0.000      -5.8885    -4.92324
------------------------------------------------------------------------------
(Etolev2==0 is the base outcome)
```

Table B.88 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,.2}$) Prcponafter = Constant + X_1 Eto*

```
Iteration 0:   log likelihood = -2014.3924
Iteration 1:   log likelihood = -1905.0692
Iteration 2:   log likelihood = -1891.1502
Iteration 3:   log likelihood = -1890.7553
Iteration 4:   log likelihood = -1890.7545

Multinomial logistic regression                   Number of obs   =       8360
                                                  LR chi2(2)      =     247.28
                                                  Prob > chi2     =     0.0000
Log likelihood = -1890.7545                       Pseudo R2       =     0.0614
------------------------------------------------------------------------------
 Prcponafter |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |  -5.842102   .5413586   -10.79   0.000    -6.903145   -4.781059
       _cons |  -2.086701    .128957   -16.18   0.000    -2.339452    -1.83395
-------------+----------------------------------------------------------------
2            |
         Eto |   -4.62413   .4964754    -9.31   0.000    -5.597204   -3.651057
       _cons |  -2.331043   .1299253   -17.94   0.000    -2.585692   -2.076394
------------------------------------------------------------------------------
(Prcponafter==0 is the base outcome)
```

Table B.89 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,.2}$) Prcponafter = Constant + X_1 EtoPerCh*

```
Iteration 0:   log likelihood = -2001.4636
Iteration 1:   log likelihood = -1984.9464
Iteration 2:   log likelihood = -1955.7846
Iteration 3:   log likelihood = -1953.0359
Iteration 4:   log likelihood = -1953.0088
Iteration 5:   log likelihood = -1953.0088

Multinomial logistic regression                   Number of obs   =       8320
                                                  LR chi2(2)      =      96.91
                                                  Prob > chi2     =     0.0000
Log likelihood = -1953.0088                       Pseudo R2       =     0.0242

------------------------------------------------------------------------------
 Prcponafter |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
    EtoPerCh |  -.8706363   .1909963    -4.56   0.000    -1.244982   -.4962905
       _cons |  -3.599798   .0704814   -51.07   0.000    -3.737939   -3.461657
-------------+----------------------------------------------------------------
2            |
    EtoPerCh |   .2469805   .0293121     8.43   0.000     .1895297    .3044312
       _cons |  -3.689314   .0720191   -51.23   0.000    -3.830468   -3.548159
------------------------------------------------------------------------------
(Prcponafter==0 is the base outcome)
```

Table B.90 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,.2}$) Prcpbefafter = Constant + X_1 Eto*

```
Iteration 0:   log likelihood =  -1885.824
Iteration 1:   log likelihood = -1820.2256
Iteration 2:   log likelihood = -1814.8146
Iteration 3:   log likelihood =  -1814.749
Iteration 4:   log likelihood =  -1814.749

Multinomial logistic regression                   Number of obs   =       8334
                                                  LR chi2(2)      =     142.15
                                                  Prob > chi2     =     0.0000
Log likelihood =  -1814.749                       Pseudo R2       =     0.0377
------------------------------------------------------------------------------
Prcpbefafter |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
         Eto |  -3.446569   .4845066    -7.11   0.000    -4.396184   -2.496953
       _cons |  -2.705044   .1383579   -19.55   0.000    -2.976221   -2.433868
-------------+----------------------------------------------------------------
2            |
         Eto |  -4.410685   .5101193    -8.65   0.000    -5.410501    -3.41087
       _cons |  -2.466706   .1349622   -18.28   0.000    -2.731227   -2.202185
------------------------------------------------------------------------------
(Prcpbefafter==0 is the base outcome)
```

Table B.91 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,.2}$) Prcpbefafter = Constant + X_1 EtoPerCh*

```
Iteration 0:   log likelihood = -1880.1787
Iteration 1:   log likelihood =  -1871.493
Iteration 2:   log likelihood = -1851.7028
Iteration 3:   log likelihood = -1851.0946
Iteration 4:   log likelihood = -1851.0943
Iteration 5:   log likelihood = -1851.0943

Multinomial logistic regression                   Number of obs   =       8294
                                                  LR chi2(2)      =      58.17
                                                  Prob > chi2     =     0.0000
Log likelihood = -1851.0943                       Pseudo R2       =     0.0155

------------------------------------------------------------------------------
Prcpbefafter |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
    EtoPerCh |   .0194308   .0775424     0.25   0.802    -.1325496    .1714112
       _cons |  -3.683197   .0726342   -50.71   0.000    -3.825557   -3.540836
-------------+----------------------------------------------------------------
2            |
    EtoPerCh |    .237417   .0302441     7.85   0.000     .1781397    .2966943
       _cons |  -3.763158   .0746327   -50.42   0.000    -3.909435    -3.61688
------------------------------------------------------------------------------
(Prcpbefafter==0 is the base outcome)
```

Table B.92 - Brawley-Calipatria (1982-2004) multinomial logistic regression model results, *(Logit $Y_{0,1}$) PrcpOn = Constant + X_1 EtoPerCh*

```
Iteration 0:   log likelihood = -1001.8176
Iteration 1:   log likelihood =  -995.1328
Iteration 2:   log likelihood = -988.27875
Iteration 3:   log likelihood = -986.80983
Iteration 4:   log likelihood = -986.78744
Iteration 5:   log likelihood = -986.78743

Logistic regression                               Number of obs   =       8320
                                                  LR chi2(1)      =      30.06
                                                  Prob > chi2     =     0.0000
Log likelihood = -986.78743                       Pseudo R2       =     0.0150

------------------------------------------------------------------------------
      PrcpOn |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    EtoPerCh |  -.9018303   .1915966    -4.71   0.000    -1.277353   -.5263077
       _cons |  -3.621587   .0704322   -51.42   0.000    -3.759631   -3.483542
------------------------------------------------------------------------------
```

Table B.93 - Model parameters for the specific gravity and evaporation relationship

Specific Gravity	Specific Gravity Evaporation Multiplier
1.000	1.000
1.050	0.963
1.100	0.926
1.150	0.880
1.200	0.833
1.250	0.785
1.300	0.737
1.350	0.688
1.400	0.640

Table B.94 - Initial model parameters for TDS and phosphorous in mg/L

Location	TDS (mg/L)	Phosphorous (mg/L)
Alamo River	2,600	0.574*
Alamo River Ag Drains	2,600	0.840**
Alamo Canal	2,600	RANDOM(0.5,0.4)(**)
New River Wetlands	3,900	0.810**
New River Ag Drains	3,900	0.780**
New River U.S.A./Mexico Border	3,900	1.420**
Whitewater River	1,600	0.530*
All American Canal	RANDOM(750,775)	0.470(**)
Coachella Valley Aquifer	750	0.574(*)
Coachella Canal	900	0.574(*)
Agricultural Runoff	1,500	0.840**
Salton Sea	39,000	N/A

*Weghorst 2002
**Imperial Irrigation Decision Support System Summary Report/CH2MHILL 2001

Table B.95 - Salton Sea model projected population growth data for the Imperial Valley and Mexicali (based on Pick et al. 2003)

Year	IV Population Growth	Mexicali Population Growth
2005	159269	852491
2006	162885	871246
2007	166582	890413
2008	170364	910002
2009	174231	930022
2010	178186	950482
2011	182231	971393
2012	186367	992764
2013	190598	1.02E+06
2014	194925	1.04E+06
2015	199349	1.06E+06
2016	203875	1.08E+06
2017	208503	1.11E+06
2018	213236	1.13E+06
2019	218076	1.16E+06
2020	223026	1.18E+06
2021	228089	1.21E+06
2022	233267	1.23E+06
2023	238562	1.26E+06
2024	243977	1.29E+06

Table B.96 - Real baseline wetland increase (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-235.19	0.00	0.00	-235.19	-235.19	-235.20	-235.18
	Total	200	-235.29	0.10	0.01	-235.30	-235.27	-235.39	-235.18
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	58,990	6	1	58,989	58,991	58,980	59,003
	Total	200	59,141	151	11	59,120	59,162	58,980	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	74,436	12,367	1,237	71,982	76,890	42,461	110,079
	Total	200	73,943	11,588	819	72,328	75,559	42,461	110,079
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,873	2,202	220	25,436	26,310	19,654	31,924
	Total	200	25,786	2,063	146	25,499	26,074	19,654	31,924
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	86,176,013	2,254,453	225,445	85,728,681	86,623,346	78,088,017	88,441,726
	Total	200	85,997,754	2,016,556	142,592	85,716,569	86,278,940	76,821,611	88,441,726
Sargo	1	100	11	2	0	10	11	7	14
	2	100	46	7	1	44	47	25	66
	Total	200	28	18	1	26	31	7	66
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	215	32	3	209	222	118	301
	Total	200	213	29	2	209	217	118	301
Corvina	1	100	8	1	0	7	8	5	10
	2	100	32	5	1	31	33	17	46
	Total	200	20	13	1	18	21	5	46
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	77,677,427	15,153,662	1,515,366	74,670,611	80,684,242	41,707,821	131,269,736
	Total	200	78,099,427	13,997,401	989,766	76,147,652	80,051,202	41,707,821	131,269,736
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.74	0.16	0.02	0.70	0.77	0.32	1.33
	Total	200	0.74	0.15	0.01	0.72	0.76	0.32	1.33
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	65.45	8.89	0.89	63.69	67.21	45.00	86.00
	Total	200	65.72	8.50	0.60	64.53	66.90	45.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	62.63	8.79	0.88	60.89	64.37	44.96	82.16
	Total	200	62.84	8.70	0.62	61.62	64.05	44.49	86.54

Table B.97 - Real baseline wetland increase (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	1.9	1	1.9	91179.1	0.000
	Within Groups	0.0	198	0.0		
	Total	1.9	199			
Salinity	Between Groups	4559822.5	1	4559822.5	155974.5	0.000
	Within Groups	5788.4	198	29.2		
	Total	4565610.9	199			
AWPPopSize	Between Groups	48509161.8	1	48509161.8	0.4	0.549
	Within Groups	26675135066.5	198	134722904.4		
	Total	26723644228.3	199			
CBPPopSize	Between Groups	1502292.7	1	1502292.7	0.4	0.554
	Within Groups	845236900.1	198	4268873.2		
	Total	846739192.8	199			
Tilapia	Between Groups	6355249367556.9	1	6355249367556.9	1.6	0.212
	Within Groups	802877827390626.0	198	4054938522174.9		
	Total	809233076758182.0	199			
Sargo	Between Groups	61493.1	1	61493.1	2247.9	0.000
	Within Groups	5416.5	198	27.4		
	Total	66909.7	199			
Bairdiella	Between Groups	1000.8	1	1000.8	1.2	0.284
	Within Groups	171356.6	198	865.4		
	Total	172357.4	199			
Corvina	Between Groups	29547.6	1	29547.6	2125.7	0.000
	Within Groups	2752.2	198	13.9		
	Total	32299.8	199			
FishKilled	Between Groups	35616885016176.1	1	35616885016176.1	0.2	0.671
	Within Groups	38953904541971000.0	198	196736891626116.0		
	Total	38989521426987100.0	199			
FishKill Percent	Between Groups	0.0	1	0.0	0.2	0.684
	Within Groups	4.5	198	0.0		
	Total	4.5	199			
DeathAlgal FishKills	Between Groups	14.0	1	14.0	0.2	0.660
	Within Groups	14358.7	198	72.5		
	Total	14372.8	199			
DeathAlgal FishKillIndex	Between Groups	8.5	1	8.5	0.1	0.738
	Within Groups	15055.7	198	76.0		
	Total	15064.2	199			

Table B.98 - Impoundment scenarios (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
North Elev	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-220.00	0.00	0.00	-220.00	-220.00	-220.00	-220.00
	3	100	-220.00	0.00	0.00	-220.00	-220.00	-220.00	-220.00
	Total	300	-225.13	7.26	0.42	-225.95	-224.30	-235.39	-220.00
South Elev	1	0	.	.	.	.	.	.	.
	2	100	-232.00	0.00	0.00	-232.00	-232.00	-232.00	-232.00
	3	100	-251.00	0.00	0.00	-251.00	-251.00	-251.00	-251.00
	Total	200	-241.50	9.52	0.67	-242.83	-240.17	-251.00	-232.00
North Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	7,262	1	0	7,262	7,262	7,260	7,264
	3	100	15,083	2	0	15,082	15,083	15,079	15,087
	Total	300	27,212	22,946	1,325	24,605	29,819	7,260	59,306
South Salinity	1	0	.	.	.	.	.	.	.
	2	100	101,281	11	1	101,278	101,283	101,251	101,311
	3	100	213,114	50	5	213,104	213,124	212,960	213,223
	Total	200	157,197	56,057	3,964	149,381	165,014	101,251	213,223
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	81,341	10,234	1,023	79,311	83,372	52,479	105,376
	3	100	80,081	10,543	1,054	77,989	82,173	52,404	108,691
	Total	300	78,291	11,049	638	77,036	79,547	49,910	108,691
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	27,181	1,761	176	26,831	27,530	21,812	31,243
	3	100	26,979	1,790	179	26,624	27,335	22,062	31,370
	Total	300	26,620	1,934	112	26,400	26,840	21,433	31,370
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	87,627,112	705,694	70,569	87,487,087	87,767,137	85,280,718	88,567,303
	3	100	87,400,467	1,004,155	100,416	87,201,221	87,599,713	83,412,242	88,545,882
	Total	300	86,949,025	1,466,203	84,651	86,782,437	87,115,612	76,821,611	88,567,303
Sargo	1	100	11	2	0	10	11	7	14
	2	100	270,186	27,464	2,746	264,736	275,635	194,697	328,331
	3	100	260,805	27,232	2,723	255,401	266,208	190,951	337,570
	Total	300	177,000	127,378	7,354	162,528	191,473	7	337,570
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	1,099,426	97,868	9,787	1,080,007	1,118,845	840,669	1,312,478
	3	100	1,071,524	99,593	9,959	1,051,763	1,091,285	827,090	1,343,813
	Total	300	723,720	518,839	29,955	664,771	782,670	154	1,343,813
Corvina	1	100	8	1	0	7	8	5	10
	2	100	218	24	2	214	223	151	275
	3	100	214	24	2	209	219	151	278
	Total	300	147	100	6	135	158	5	278

Table B.98 - (Continued)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	65,949,912	10,995,036	1,099,504	63,768,258	68,131,566	41,866,961	101,338,366
	3	100	67,506,656	11,065,180	1,106,518	65,311,084	69,702,228	42,653,121	99,352,396
	Total	300	70,659,332	12,893,028	744,379	69,194,446	72,124,218	41,866,961	110,607,852
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.54	0.12	0.01	0.52	0.56	0.31	0.90
	3	100	0.56	0.12	0.01	0.54	0.59	0.28	0.90
	Total	300	0.62	0.15	0.01	0.60	0.63	0.28	1.12
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	50.06	6.47	0.65	48.78	51.34	39.00	68.00
	3	100	50.10	7.78	0.78	48.56	51.64	26.03	69.00
	Total	300	55.38	10.59	0.61	54.18	56.58	26.03	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	48.24	6.29	0.63	46.99	49.49	36.68	64.50
	3	100	48.23	7.56	0.76	46.73	49.73	26.53	65.00
	Total	300	53.17	10.28	0.59	52.00	54.34	26.53	86.54

Table B.99 - Impoundment scenarios (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
North Elev	Between Groups	15773.5	2	7886.8	1346962732.2	0.000
	Within Groups	0.0	297	0.0		
	Total	15773.5	299			
South Elev	Between Groups	18050.0	1	18050.0	.	.
	Within Groups	0.0	198	0.0		
	Total	18050.0	199			
North Salinity	Between Groups	157423311235.0	2	78711655617.5	7803823757.4	0.000
	Within Groups	2995.6	297	10.1		
	Total	157423314230.6	299			
South Salinity	Between Groups	625332753584.3	1	625332753584.3	480443698.2	0.000
	Within Groups	257711.5	198	1301.6		
	Total	625333011295.9	199			
AWPPopSize	Between Groups	3593534179.4	2	1796767089.7	16.2	0.000
	Within Groups	32908025662.5	297	110801433.2		
	Total	36501559842.0	299			
CBPPopSize	Between Groups	129031359.7	2	64515679.9	19.4	0.000
	Within Groups	989452026.5	297	3331488.3		
	Total	1118483386.2	299			
Tilapia	Between Groups	193943852360389.0	2	96971926180194.4	64.2	0.000
	Within Groups	448831476274579.0	297	1511217091833.6		
	Total	642775328634968.0	299			
Sargo	Between Groups	4703203202586.6	2	2351601601293.3	4716.2	0.000
	Within Groups	148090924451.3	297	498622641.3		
	Total	4851294127037.9	299			
Bairdiella	Between Groups	78558857316636.2	2	39279428658318.1	6044.0	0.000
	Within Groups	1930186209461.7	297	6498943466.2		
	Total	80489043526097.8	299			
Corvina	Between Groups	2900399.5	2	1450199.8	3717.2	0.000
	Within Groups	115870.5	297	390.1		
	Total	3016270.0	299			
FishKilled	Between Groups	9393054888899350.0	2	4696527444449670.0	34.6	0.000
	Within Groups	40309765097943800.0	297	135723114807892.0		
	Total	49702819986843200.0	299			
FishKill Percent	Between Groups	2.5	2	1.2	82.4	0.000
	Within Groups	4.5	297	0.0		
	Total	7.0	299			
DeathAlgal FishKills	Between Groups	16853.8	2	8426.9	150.1	0.000
	Within Groups	16679.2	297	56.2		
	Total	33532.9	299			
DeathAlgal FishKillIndex	Between Groups	14618.0	2	7309.0	127.8	0.000
	Within Groups	16981.7	297	57.2		
	Total	31599.7	299			

Table B.100 - Impoundment scenarios (strategy 1): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
North Elev	1	2	-15.38190(*)	0.000	0	-15.383	-15.381
		3	-15.38190(*)	0.000	0	-15.383	-15.381
	2	1	15.38190(*)	0.000	0	15.381	15.383
		3	0	0.000	1	-0.001	0.001
	3	1	15.38190(*)	0.000	0	15.381	15.383
		2	0	0.000	1	-0.001	0.001
North Salinity	1	2	52029.77150(*)	0.449	0	52028.690	52030.853
		3	44209.02840(*)	0.449	0	44207.947	44210.110
	2	1	-52029.77150(*)	0.449	0	-52030.853	-52028.690
		3	-7820.74310(*)	0.449	0	-7821.825	-7819.662
	3	1	-44209.02840(*)	0.449	0	-44210.110	-44207.947
		2	7820.74310(*)	0.449	0	7819.662	7821.825
AWPPopSize	1	2	-7890.31350(*)	1488.633	0	-11474.373	-4306.254
		3	-6630.34340(*)	1488.633	0	-10214.403	-3046.284
	2	1	7890.31350(*)	1488.633	0	4306.254	11474.373
		3	1259.9701	1488.633	1	-2324.089	4844.029
	3	1	6630.34340(*)	1488.633	0	3046.284	10214.403
		2	-1259.9701	1488.633	1	-4844.029	2324.089
CBPPopSize	1	2	-1480.81810(*)	258.127	0	-2102.290	-859.346
		3	-1279.71760(*)	258.127	0	-1901.190	-658.246
	2	1	1480.81810(*)	258.127	0	859.346	2102.290
		3	201.1005	258.127	1	-420.372	822.573
	3	1	1279.71760(*)	258.127	0	658.246	1901.190
		2	-201.1005	258.127	1	-822.573	420.372
Tilapia	1	2	-1807616.23930(*)	173851.494	0	-2226184.130	-1389048.349
		3	-1580971.64050(*)	173851.494	0	-1999539.531	-1162403.750
	2	1	1807616.23930(*)	173851.494	0	1389048.349	2226184.130
		3	226644.5988	173851.494	0.58	-191923.292	645212.489
	3	1	1580971.64050(*)	173851.494	0	1162403.750	1999539.531
		2	-226644.5988	173851.494	0.58	-645212.489	191923.292
Sargo	1	2	-270175.11460(*)	3157.919	0	-277778.176	-262572.054
		3	-260793.97570(*)	3157.919	0	-268397.037	-253190.915
	2	1	270175.11460(*)	3157.919	0	262572.054	277778.176
		3	9381.13890(*)	3157.919	0.01	1778.078	16984.200
	3	1	260793.97570(*)	3157.919	0	253190.915	268397.037
		2	-9381.13890(*)	3157.919	0.01	-16984.200	-1778.078
Bairdiella	1	2	-1099215.63150(*)	11400.828	0	-1126664.463	-1071766.800
		3	-1071313.29430(*)	11400.828	0	-1098762.126	-1043864.463
	2	1	1099215.63150(*)	11400.828	0	1071766.800	1126664.463
		3	27902.33720(*)	11400.828	0.045	453.506	55351.169
	3	1	1071313.29430(*)	11400.828	0	1043864.463	1098762.126
		2	-27902.33720(*)	11400.828	0.045	-55351.169	-453.506
Corvina	1	2	-210.90920(*)	2.793	0	-217.635	-204.184
		3	-206.17190(*)	2.793	0	-212.897	-199.447
	2	1	210.90920(*)	2.793	0	204.184	217.635
		3	4.7373	2.793	0.273	-1.988	11.463
	3	1	206.17190(*)	2.793	0	199.447	212.897
		2	-4.7373	2.793	0.273	-11.463	1.988

Table B.100 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
FishKilled	1	2	12571515.54500(*)	1647562.532	0	8604815.235	16538215.855
		3	11014771.51850(*)	1647562.532	0	7048071.209	14981471.828
	2	1	-12571515.54500(*)	1647562.532	0	-16538215.855	-8604815.235
		3	-1556744.027	1647562.532	1	-5523444.336	2409956.283
	3	1	-11014771.51850(*)	1647562.532	0	-14981471.828	-7048071.209
		2	1556744.027	1647562.532	1	-2409956.283	5523444.336
FishKillPercent	1	2	.20420(*)	0.017	0	0.162	0.246
		3	.18050(*)	0.017	0	0.139	0.222
	2	1	-.20420(*)	0.017	0	-0.246	-0.162
		3	-0.0237	0.017	0.523	-0.066	0.018
	3	1	-.18050(*)	0.017	0	-0.222	-0.139
		2	0.0237	0.017	0.523	-0.018	0.066
DeathAlgal FishKills	1	2	15.920(*)	1.060	0	13.370	18.470
		3	15.880(*)	1.060	0	13.330	18.430
	2	1	-15.920(*)	1.060	0	-18.470	-13.370
		3	-0.04	1.060	1	-2.590	2.510
	3	1	-15.880(*)	1.060	0	-18.430	-13.330
		2	0.04	1.060	1	-2.510	2.590
DeathAlgal FishKillIndex	1	2	14.80230(*)	1.069	0	12.228	17.377
		3	14.81320(*)	1.069	0	12.239	17.388
	2	1	-14.80230(*)	1.069	0	-17.377	-12.228
		3	0.0109	1.069	1	-2.564	2.586
	3	1	-14.81320(*)	1.069	0	-17.388	-12.239
		2	-0.0109	1.069	1	-2.586	2.564

* The mean difference is significant at the .05 level.

Table B.101 - Baseline (1) versus impoundment scenarios 2 & 3 (strategy 2): Oneway ANOVA descriptives

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
North Elev	1	100	-235.36	1.00	0.10	-235.55	-235.16	-238.18	-233.23
	2	100	-220.00	0.00	0.00	-220.00	-220.00	-220.00	-220.00
	3	100	-220.00	0.00	0.00	-220.00	-220.00	-220.00	-220.00
	Total	300	-225.12	7.27	0.42	-225.95	-224.29	-238.18	-220.00
South Elev	1	0	.	.	.	.	.	.	.
	2	100	-231.63	1.16	0.12	-231.86	-231.40	-235.00	-229.00
	3	100	-249.90	0.99	0.10	-250.10	-249.70	-252.00	-248.00
	Total	200	-240.77	9.22	0.65	-242.05	-239.48	-252.00	-229.00
North Salinity	1	100	59,025	1,450	145	58,737	59,312	56,073	63,380
	2	100	7,101	178	18	7,066	7,137	6,690	7,532
	3	100	14,949	337	34	14,882	15,016	14,145	15,712
	Total	300	27,025	22,907	1,323	24,422	29,628	6,690	63,380
South Salinity	1	0	.	.	.	.	.	.	.
	2	100	98,113	3,835	384	97,352	98,874	90,228	109,738
	3	100	194,827	10,014	1,001	192,840	196,814	175,912	222,221
	Total	200	146,470	49,065	3,469	139,628	153,312	90,228	222,221
AWPPopSize	1	100	72,775	11,918	1,192	70,410	75,139	45,645	105,085
	2	100	79,791	10,935	1,093	77,622	81,961	51,511	104,908
	3	100	79,286	10,479	1,048	77,207	81,365	52,464	104,968
	Total	300	77,284	11,542	666	75,973	78,595	45,645	105,085
CBPPopSize	1	100	25,605	2,121	212	25,184	26,025	20,168	30,839
	2	100	26,919	1,893	189	26,544	27,295	21,545	31,060
	3	100	26,842	1,807	181	26,483	27,200	21,638	31,176
	Total	300	26,455	2,030	117	26,225	26,686	20,168	31,176
Tilapia	1	100	81,375,989	8,065,973	806,597	79,775,525	82,976,453	43,016,635	88,380,289
	2	100	87,412,243	845,160	84,516	87,244,545	87,579,941	84,543,096	88,485,879
	3	100	87,480,979	837,479	83,748	87,314,805	87,647,153	83,947,828	88,564,544
	Total	300	85,423,070	5,497,993	317,427	84,798,397	86,047,744	43,016,635	88,564,544
Sargo	1	100	23	23	2	18	27	0	68
	2	100	244,741	60,936	6,094	232,650	256,832	147,558	636,833
	3	100	232,431	54,970	5,497	221,524	243,338	157,766	639,323
	Total	300	159,065	122,249	7,058	145,175	172,955	0	639,323
Bairdiella	1	100	210	36	4	203	217	139	347
	2	100	982,989	305,000	30,500	922,470	1,043,508	576,085	2,883,956
	3	100	928,655	256,666	25,667	877,727	979,583	597,315	2,587,288
	Total	300	637,285	506,673	29,253	579,717	694,852	139	2,883,956
Corvina	1	100	16	16	2	13	19	0	42
	2	100	209	28	3	204	215	133	291
	3	100	207	26	3	202	212	137	296
	Total	300	144	94	5	133	155	0	296

Table B.101 - (Continued)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
FishKilled	1	100	78,843,986	13,795,039	1,379,504	76,106,751	81,581,221	49,359,552	120,357,913
	2	100	68,134,177	12,481,441	1,248,144	65,657,588	70,610,765	42,502,689	108,323,195
	3	100	68,300,521	11,506,245	1,150,625	66,017,433	70,583,610	42,933,709	107,791,642
	Total	300	71,759,561	13,550,300	782,327	70,219,997	73,299,126	42,502,689	120,357,913
FishKill Percent	1	100	0.75	0.16	0.02	0.72	0.79	0.44	1.18
	2	100	0.57	0.13	0.01	0.54	0.59	0.28	1.00
	3	100	0.57	0.12	0.01	0.54	0.59	0.34	0.93
	Total	300	0.63	0.16	0.01	0.61	0.65	0.28	1.18
DeathAlgal FishKills	1	100	65.54	8.10	0.81	63.93	67.15	44.00	90.00
	2	100	50.01	7.77	0.78	48.47	51.55	32.00	77.00
	3	100	49.86	6.85	0.69	48.50	51.21	36.00	67.00
	Total	300	55.14	10.56	0.61	53.93	56.34	32.00	90.00
DeathAlgal FishKillIndex	1	100	62.25	8.10	0.81	60.64	63.86	41.81	85.06
	2	100	48.00	7.44	0.74	46.52	49.48	31.06	73.97
	3	100	47.92	6.72	0.67	46.59	49.25	34.06	67.67
	Total	300	52.72	10.03	0.58	51.58	53.86	31.06	85.06

Table B.102 - Impoundment scenarios (strategy 2): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
North Elev	Between Groups	15720.2	2	7860.1	23673.4	0.000
	Within Groups	98.6	297	0.3		
	Total	15818.9	299			
South Elev	Between Groups	16689.6	1	16689.6	14348.3	0.000
	Within Groups	230.3	198	1.2		
	Total	16920.0	199			
North Salinity	Between Groups	156676773813.6	2	78338386906.8	104551.9	0.000
	Within Groups	222535335.6	297	749277.2		
	Total	156899309149.2	299			
South Salinity	Between Groups	467680574535.4	1	467680574535.4	8134.5	0.000
	Within Groups	11383647095.4	198	57493167.1		
	Total	479064221630.7	199			
AWPPopSize	Between Groups	3063036644.2	2	1531518322.1	12.4	0.000
	Within Groups	36770159184.8	297	123805249.8		
	Total	39833195829.0	299			
CBPPopSize	Between Groups	108815733.4	2	54407866.7	14.4	0.000
	Within Groups	1123121989.0	297	3781555.5		
	Total	1231937722.4	299			
Tilapia	Between Groups	2457066342368390.0	2	1228533171184190.0	55.4	0.000
	Within Groups	6581082835556470.0	297	22158528065846.7		
	Total	9038149177924860.0	299			
Sargo	Between Groups	3801744670844.4	2	1900872335422.2	846.7	0.000
	Within Groups	666746740214.7	297	2244938519.2		
	Total	4468491411059.1	299			
Bairdiella	Between Groups	61027209543554.7	2	30513604771777.3	576.1	0.000
	Within Groups	15731349505743.9	297	52967506753.3		
	Total	76758559049298.5	299			
Corvina	Between Groups	2463163.0	2	1231581.5	2144.2	0.000
	Within Groups	170588.1	297	574.4		
	Total	2633751.1	299			
FishKilled	Between Groups	7529744193028560.0	2	3764872096514280.0	23.6	0.000
	Within Groups	47369830188796900.0	297	159494377740057.0		
	Total	54899574381825400.0	299			
FishKill Percent	Between Groups	2.3	2	1.2	63.9	0.000
	Within Groups	5.4	297	0.0		
	Total	7.7	299			
DeathAlgal FishKills	Between Groups	16240.8	2	8120.4	140.8	0.000
	Within Groups	17129.0	297	57.7		
	Total	33369.8	299			
DeathAlgal FishKillIndex	Between Groups	13611.6	2	6805.8	122.9	0.000
	Within Groups	16450.5	297	55.4		
	Total	30062.0	299			

Table B.103 - Impoundment scenarios (strategy 2): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
North Elev	1	2	-15.35590(*)	0.081	0	-15.552	-15.160
		3	-15.35590(*)	0.081	0	-15.552	-15.160
	2	1	15.35590(*)	0.081	0	15.160	15.552
		3	0	0.081	1	-0.196	0.196
	3	1	15.35590(*)	0.081	0	15.160	15.552
		2	0	0.081	1	-0.196	0.196
North Salinity	1	2	51923.28490(*)	122.415	0	51628.555	52218.015
		3	44076.02820(*)	122.415	0	43781.299	44370.758
	2	1	-51923.28490(*)	122.415	0	-52218.015	-51628.555
		3	-7847.25670(*)	122.415	0	-8141.986	-7552.527
	3	1	-44076.02820(*)	122.415	0	-44370.758	-43781.299
		2	7847.25670(*)	122.415	0	7552.527	8141.986
AWPPopSize	1	2	-7016.92190(*)	1573.564	0	-10805.463	-3228.381
		3	-6511.40200(*)	1573.564	0	-10299.943	-2722.861
	2	1	7016.92190(*)	1573.564	0	3228.381	10805.463
		3	505.5199	1573.564	1	-3283.021	4294.061
	3	1	6511.40200(*)	1573.564	0	2722.861	10299.943
		2	-505.5199	1573.564	1	-4294.061	3283.021
CBPPopSize	1	2	-1314.63790(*)	275.011	0	-1976.759	-652.516
		3	-1237.00110(*)	275.011	0	-1899.123	-574.880
	2	1	1314.63790(*)	275.011	0	652.516	1976.759
		3	77.6368	275.011	1	-584.485	739.758
	3	1	1237.00110(*)	275.011	0	574.880	1899.123
		2	-77.6368	275.011	1	-739.758	584.485
Tilapia	1	2	-6036254.11570(*)	665710.569	0	-7639030.501	-4433477.730
		3	-6104989.91900(*)	665710.569	0	-7707766.304	-4502213.534
	2	1	6036254.11570(*)	665710.569	0	4433477.730	7639030.501
		3	-68735.8033	665710.569	1	-1671512.189	1534040.582
	3	1	6104989.91900(*)	665710.569	0	4502213.534	7707766.304
		2	68735.8033	665710.569	1	-1534040.582	1671512.189
Sargo	1	2	-244718.47640(*)	6700.654	0	-260851.089	-228585.864
		3	-232408.41150(*)	6700.654	0	-248541.024	-216275.799
	2	1	244718.47640(*)	6700.654	0	228585.864	260851.089
		3	12310.0649	6700.654	0.202	-3822.548	28442.678
	3	1	232408.41150(*)	6700.654	0	216275.799	248541.024
		2	-12310.0649	6700.654	0.202	-28442.678	3822.548
Bairdiella	1	2	-982778.92070(*)	32547.659	0	-1061141.234	-904416.608
		3	-928444.76340(*)	32547.659	0	-1006807.076	-850082.450
	2	1	982778.92070(*)	32547.659	0	904416.608	1061141.234
		3	54334.1573	32547.659	0.288	-24028.156	132696.470
	3	1	928444.76340(*)	32547.659	0	850082.450	1006807.076
		2	-54334.1573	32547.659	0.288	-132696.470	24028.156

Table B.103 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Corvina	1	2	-193.49160(*)	3.389	0	-201.652	-185.331
		3	-190.91690(*)	3.389	0	-199.077	-182.757
	2	1	193.49160(*)	3.389	0	185.331	201.652
		3	2.5747	3.389	1	-5.586	10.735
	3	1	190.91690(*)	3.389	0	182.757	199.077
		2	-2.5747	3.389	1	-10.735	5.586
FishKilled	1	2	10709809.11280(*)	1786025.631	0	6409742.628	15009875.597
		3	10543464.51760(*)	1786025.631	0	6243398.033	14843531.002
	2	1	-10709809.11280(*)	1786025.631	0	-15009875.597	-6409742.628
		3	-166344.5952	1786025.631	1	-4466411.080	4133721.889
	3	1	-10543464.51760(*)	1786025.631	0	-14843531.002	-6243398.033
		2	166344.5952	1786025.631	1	-4133721.889	4466411.080
FishKillPercent	1	2	.18690(*)	0.019	0	0.141	0.233
		3	.18650(*)	0.019	0	0.141	0.232
	2	1	-.18690(*)	0.019	0	-0.233	-0.141
		3	-0.0004	0.019	1	-0.046	0.046
	3	1	-.18650(*)	0.019	0	-0.232	-0.141
		2	0.0004	0.019	1	-0.046	0.046
DeathAlgal FishKills	1	2	15.530(*)	1.074	0	12.940	18.120
		3	15.685(*)	1.074	0	13.100	18.270
	2	1	-15.530(*)	1.074	0	-18.120	-12.940
		3	0.155	1.074	1	-2.430	2.740
	3	1	-15.685(*)	1.074	0	-18.270	-13.100
		2	-0.155	1.074	1	-2.740	2.430
DeathAlgal FishKillIndex	1	2	14.24790(*)	1.053	0	11.714	16.782
		3	14.32960(*)	1.053	0	11.796	16.864
	2	1	-14.24790(*)	1.053	0	-16.782	-11.714
		3	0.0817	1.053	1	-2.452	2.616
	3	1	-14.32960(*)	1.053	0	-16.864	-11.796
		2	-0.0817	1.053	1	-2.616	2.452

* The mean difference is significant at the .05 level.

Table B.104 - Canal lining scenario 2 – no fallowing or mitigating (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-227.25	0.00	0.00	-227.25	-227.25	-227.26	-227.24
	Total	200	-231.32	4.08	0.29	-231.88	-230.75	-235.39	-227.24
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	49,681	3	0	49,680	49,681	49,672	49,689
	Total	200	54,486	4,818	341	53,814	55,158	49,672	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	71,812	10,992	1,099	69,631	73,993	49,857	97,602
	Total	200	72,631	10,897	771	71,112	74,151	49,857	98,473
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,464	1,952	195	25,076	25,851	21,215	29,965
	Total	200	25,582	1,935	137	25,312	25,852	21,215	29,965
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	86,409,242	1,629,883	162,988	86,085,838	86,732,646	78,915,882	88,470,304
	Total	200	86,114,369	1,707,345	120,727	85,876,299	86,352,438	76,821,611	88,470,304
Sargo	1	100	11	2	0	10	11	7	14
	2	100	56	7	1	54	57	40	74
	Total	200	33	23	2	30	36	7	74
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	241	29	3	236	247	176	319
	Total	200	226	31	2	222	230	154	319
Corvina	1	100	8	1	0	7	8	5	10
	2	100	32	4	0	32	33	23	44
	Total	200	20	13	1	18	22	5	44
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	79,372,480	12,542,712	1,254,271	76,883,734	81,861,226	52,653,110	109,077,864
	Total	200	78,946,954	12,647,333	894,301	77,183,430	80,710,477	52,653,110	110,607,852
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.75	0.13	0.01	0.72	0.77	0.45	1.07
	Total	200	0.75	0.13	0.01	0.73	0.76	0.45	1.12
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	59.38	7.67	0.77	57.86	60.90	39.00	77.00
	Total	200	62.68	8.55	0.60	61.49	63.87	39.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	55.99	7.53	0.75	54.49	57.48	33.51	71.41
	Total	200	59.51	8.83	0.62	58.28	60.75	33.51	86.54

Table B.105 - Canal lining scenario 2 – no fallowing or mitigating (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	3305.3	1	3305.3	213177816.9	0.000
	Within Groups	0.0	198	0.0		
	Total	3305.3	199			
Salinity	Between Groups	4618839583.1	1	4618839583.1	245440012.9	0.000
	Within Groups	3726.1	198	18.8		
	Total	4618843309.2	199			
AWPPopSize	Between Groups	134310444.7	1	134310444.7	1.1	0.289
	Within Groups	23496267953.7	198	118668020.0		
	Total	23630578398.3	199			
CBPPopSize	Between Groups	2786471.1	1	2786471.1	0.7	0.390
	Within Groups	742272638.7	198	3748851.7		
	Total	745059109.8	199			
Tilapia	Between Groups	17390061020366.9	1	17390061020366.9	6.1	0.014
	Within Groups	562699982243610.0	198	2841919102240.5		
	Total	580090043263977.0	199			
Sargo	Between Groups	100708.5	1	100708.5	3856.4	0.000
	Within Groups	5170.7	198	26.1		
	Total	105879.2	199			
Bairdiella	Between Groups	46950.9	1	46950.9	62.5	0.000
	Within Groups	148630.3	198	750.7		
	Total	195581.2	199			
Corvina	Between Groups	31188.5	1	31188.5	3121.3	0.000
	Within Groups	1978.4	198	10.0		
	Total	33167.0	199			
FishKilled	Between Groups	36214496696606.0	1	36214496696606.0	0.2	0.635
	Within Groups	31794835472601900.0	198	160579977134353.0		
	Total	31831049969298500.0	199			
FishKill Percent	Between Groups	0.0	1	0.0	0.0	0.866
	Within Groups	3.5	198	0.0		
	Total	3.5	199			
DeathAlgal FishKills	Between Groups	2178.0	1	2178.0	34.9	0.000
	Within Groups	12369.5	198	62.5		
	Total	14547.5	199			
DeathAlgal FishKillIndex	Between Groups	2489.6	1	2489.6	37.9	0.000
	Within Groups	13023.5	198	65.8		
	Total	15513.1	199			

Table B.106 - Canal lining scenario 3 – fallowing but no mitigation (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-225.22	0.00	0.00	-225.22	-225.22	-225.22	-225.21
	Total	200	-230.30	5.10	0.36	-231.01	-229.59	-235.39	-225.21
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	47,833	3	0	47,832	47,833	47,823	47,838
	Total	200	53,562	5,744	406	52,761	54,363	47,823	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	75,367	10,761	1,076	73,232	77,502	47,583	103,234
	Total	200	74,409	10,793	763	72,904	75,914	47,583	103,234
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	26,091	1,909	191	25,712	26,469	20,654	30,670
	Total	200	25,895	1,920	136	25,627	26,163	20,654	30,670
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	86,391,103	1,787,861	178,786	86,036,352	86,745,853	79,068,945	88,530,899
	Total	200	86,105,299	1,782,790	126,062	85,856,710	86,353,888	76,821,611	88,530,899
Sargo	1	100	11	2	0	10	11	7	14
	2	100	49	7	1	48	50	32	66
	Total	200	30	20	1	27	33	7	66
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	214	28	3	209	220	144	283
	Total	200	212	27	2	209	216	144	283
Corvina	1	100	8	1	0	7	8	5	10
	2	100	33	5	0	32	34	21	45
	Total	200	20	13	1	18	22	5	45
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	75,922,515	12,825,772	1,282,577	73,377,604	78,467,427	46,779,986	115,587,240
	Total	200	77,221,971	12,846,885	908,412	75,430,622	79,013,320	46,779,986	115,587,240
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.71	0.14	0.01	0.68	0.74	0.36	1.07
	Total	200	0.73	0.14	0.01	0.71	0.75	0.36	1.12
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	61.84	8.06	0.81	60.24	63.44	43.00	83.00
	Total	200	63.91	8.34	0.59	62.75	65.07	43.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	58.20	8.21	0.82	56.57	59.83	35.29	77.94
	Total	200	60.62	8.75	0.62	59.40	61.84	35.29	86.54

Table B.107 - Canal lining scenario 3 – fallowing but no mitigation (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	5167.3	1	5167.3	247190305.8	0.000
	Within Groups	0.0	198	0.0		
	Total	5167.3	199			
Salinity	Between Groups	6565505210.6	1	6565505210.6	361298337.8	0.000
	Within Groups	3598.1	198	18.2		
	Total	6565508808.6	199			
AWPPopSize	Between Groups	183505956.8	1	183505956.8	1.6	0.210
	Within Groups	22998652718.5	198	116154811.7		
	Total	23182158675.3	199			
CBPPopSize	Between Groups	7638025.9	1	7638025.9	2.1	0.151
	Within Groups	726169180.9	198	3667521.1		
	Total	733807206.7	199			
Tilapia	Between Groups	16336746642521.3	1	16336746642521.3	5.2	0.023
	Within Groups	616152903521661.0	198	3111883351119.5		
	Total	632489650164183.0	199			
Sargo	Between Groups	73366.7	1	73366.7	3052.6	0.000
	Within Groups	4758.7	198	24.0		
	Total	78125.5	199			
Bairdiella	Between Groups	611.7	1	611.7	0.8	0.364
	Within Groups	146043.5	198	737.6		
	Total	146655.2	199			
Corvina	Between Groups	31515.1	1	31515.1	2766.6	0.000
	Within Groups	2255.5	198	11.4		
	Total	33770.6	199			
FishKilled	Between Groups	337717289900864.0	1	337717289900864.0	2.1	0.153
	Within Groups	32505733073239700.0	198	164170369056766.0		
	Total	32843450363140500.0	199			
FishKill Percent	Between Groups	0.1	1	0.1	2.7	0.104
	Within Groups	3.7	198	0.0		
	Total	3.8	199			
DeathAlgal FishKills	Between Groups	857.0	1	857.0	13.1	0.000
	Within Groups	12975.4	198	65.5		
	Total	13832.4	199			
DeathAlgal FishKillIndex	Between Groups	1172.7	1	1172.7	16.5	0.000
	Within Groups	14073.6	198	71.1		
	Total	15246.3	199			

Table B.108 - Canal lining scenario 4 – fallowing and mitigating (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-220.42	0.01	0.00	-220.42	-220.42	-220.43	-220.41
	Total	200	-227.90	7.50	0.53	-228.95	-226.85	-235.39	-220.41
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	43,878	3	0	43,878	43,879	43,871	43,887
	Total	200	51,585	7,726	546	50,508	52,662	43,871	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	72,566	10,016	1,002	70,578	74,553	51,408	96,637
	Total	200	73,008	10,396	735	71,559	74,458	49,910	98,473
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,648	1,787	179	25,293	26,003	21,807	29,754
	Total	200	25,674	1,851	131	25,416	25,932	21,433	29,917
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	86,663,685	1,520,001	152,000	86,362,084	86,965,286	82,113,225	88,529,550
	Total	200	86,241,590	1,683,600	119,048	86,006,832	86,476,349	76,821,611	88,529,550
Sargo	1	100	11	2	0	10	11	7	14
	2	100	88	11	1	85	90	66	112
	Total	200	49	39	3	44	55	7	112
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	646	80	8	631	662	489	811
	Total	200	429	226	16	397	460	154	811
Corvina	1	100	8	1	0	7	8	5	10
	2	100	36	5	0	35	37	27	46
	Total	200	22	15	1	20	24	5	46
FishKilled	1	100	78521428	12800012	1280001	75981627	81061228	53820624	110607852
	2	100	78116399	11786643	1178664	75777673	80455125	54394102	102897796
	Total	200	78318913	12274491	867938	76607378	80030449	53820624	110607852
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.72	0.13	0.01	0.70	0.75	0.44	1.03
	Total	200	0.73	0.13	0.01	0.71	0.75	0.44	1.12
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	55.55	6.70	0.67	54.22	56.88	41.00	71.00
	Total	200	60.77	9.08	0.64	59.50	62.03	41.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	52.14	6.46	0.65	50.86	53.43	39.09	68.57
	Total	200	57.59	9.37	0.66	56.29	58.90	39.09	86.54

Table B.109 - Canal lining scenario 4 – fallowing and mitigating (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	11195.8	1	11195.8	518177085.9	0.000
	Within Groups	0.0	198	0.0		
	Total	11195.8	199			
Salinity	Between Groups	11878660699.7	1	11878660699.7	648054930.8	0.000
	Within Groups	3629.3	198	18.3		
	Total	11878664329.0	199			
AWPPopSize	Between Groups	39172171.7	1	39172171.7	0.4	0.548
	Within Groups	21467111640.5	198	108419755.8		
	Total	21506283812.1	199			
CBPPopSize	Between Groups	134381.2	1	134381.2	0.0	0.844
	Within Groups	681501005.8	198	3441924.3		
	Total	681635387.0	199			
Tilapia	Between Groups	35632775942785.6	1	35632775942785.6	13.4	0.000
	Within Groups	528434445709569.0	198	2668860836917.0		
	Total	564067221652355.0	199			
Sargo	Between Groups	294959.6	1	294959.6	4644.1	0.000
	Within Groups	12575.6	198	63.5		
	Total	307535.2	199			
Bairdiella	Between Groups	9497189.0	1	9497189.0	2706.6	0.000
	Within Groups	694773.3	198	3509.0		
	Total	10191962.2	199			
Corvina	Between Groups	40654.4	1	40654.4	3518.1	0.000
	Within Groups	2288.1	198	11.6		
	Total	42942.5	199			
FishKilled	Between Groups	8202402873013.6	1	8202402873013.6	0.1	0.816
	Within Groups	29973761167862000.0	198	151382632160919.0		
	Total	29981963570735000.0	199			
FishKill Percent	Between Groups	0.0	1	0.0	1.2	0.283
	Within Groups	3.6	198	0.0		
	Total	3.6	199			
DeathAlgal FishKills	Between Groups	5439.2	1	5439.2	98.1	0.000
	Within Groups	10976.7	198	55.4		
	Total	16416.0	199			
DeathAlgal FishKillIndex	Between Groups	5939.1	1	5939.1	101.9	0.000
	Within Groups	11542.7	198	58.3		
	Total	17481.7	199			

Table B.110 - Real baseline power plant increase (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-236.13	0.00	0.00	-236.13	-236.13	-236.14	-236.12
	Total	200	-235.76	0.38	0.03	-235.81	-235.70	-236.14	-235.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	60,437	5	1	60,436	60,438	60,423	60,450
	Total	200	59,864	574	41	59,784	59,944	59,277	60,450
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	73,603	10,529	1,053	71,514	75,693	44,911	107,869
	Total	200	73,527	10,636	752	72,044	75,010	44,911	107,869
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,734	1,850	185	25,367	26,101	20,247	31,256
	Total	200	25,717	1,881	133	25,455	25,979	20,247	31,256
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	79,930,829	1,725,063	172,506	79,588,539	80,273,119	75,231,006	82,066,237
	Total	200	82,875,162	3,420,403	241,859	82,398,227	83,352,098	75,231,006	87,840,602
Sargo	1	100	11	2	0	10	11	7	14
	2	100	0	0	0	0	0	0	0
	Total	200	5	6	0	5	6	0	14
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	211	27	3	206	216	142	292
	Total	200	211	26	2	207	214	142	292
Corvina	1	100	8	1	0	7	8	5	10
	2	100	0	0	0	0	0	0	0
	Total	200	4	4	0	3	4	0	10
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	78,430,633	12,423,182	1,242,318	75,965,604	80,895,662	46,536,632	117,033,277
	Total	200	78,476,030	12,581,356	889,636	76,721,706	80,230,354	46,536,632	117,033,277
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.75	0.14	0.01	0.72	0.77	0.36	1.16
	Total	200	0.74	0.14	0.01	0.73	0.76	0.36	1.16
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	66.11	7.86	0.79	64.55	67.67	48.00	86.00
	Total	200	66.05	7.98	0.56	64.93	67.16	48.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	63.12	8.01	0.80	61.53	64.71	46.45	84.24
	Total	200	63.08	8.31	0.59	61.92	64.24	44.49	86.54

Table B.111 - Real baseline power plant increase (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	28.1	1	28.1	1855879.7	0.000
	Within Groups	0.0	198	0.0		
	Total	28.1	199			
Salinity	Between Groups	65550803.5	1	65550803.5	2332808.8	0.000
	Within Groups	5563.7	198	28.1		
	Total	65556367.2	199			
AWPPopSize	Between Groups	1162626.5	1	1162626.5	0.0	0.920
	Within Groups	22509978048.7	198	113686757.8		
	Total	22511140675.1	199			
CBPPopSize	Between Groups	58292.0	1	58292.0	0.0	0.898
	Within Groups	703915745.9	198	3555130.0		
	Total	703974037.9	199			
Tilapia	Between Groups	1733819741913460.0	1	1733819741913460.0	577.6	0.000
	Within Groups	594312924711366.0	198	3001580427835.2		
	Total	2328132666624830.0	199			
Sargo	Between Groups	5794.0	1	5794.0	5013.1	0.000
	Within Groups	228.8	198	1.2		
	Total	6022.9	199			
Bairdiella	Between Groups	1.4	1	1.4	0.0	0.965
	Within Groups	139241.7	198	703.2		
	Total	139243.1	199			
Corvina	Between Groups	2816.9	1	2816.9	4735.2	0.000
	Within Groups	117.8	198	0.6		
	Total	2934.7	199			
FishKilled	Between Groups	412179732636.5	1	412179732636.5	0.0	0.959
	Within Groups	31499401519851300.0	198	159087886463895.0		
	Total	31499813699583900.0	199			
FishKill Percent	Between Groups	0.0	1	0.0	0.0	0.938
	Within Groups	3.7	198	0.0		
	Total	3.7	199			
DeathAlgal FishKills	Between Groups	0.8	1	0.8	0.0	0.909
	Within Groups	12659.8	198	63.9		
	Total	12660.6	199			
DeathAlgal FishKillIndex	Between Groups	0.3	1	0.3	0.0	0.946
	Within Groups	13752.8	198	69.5		
	Total	13753.1	199			

Table B.112 - Real baseline brine extraction increase (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.38
	Total	200	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	59,291	4	0	59,290	59,292	59,280	59,301
	Total	200	59,291	5	0	59,291	59,292	59,277	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	72,193	11,351	1,135	69,940	74,445	50,130	107,829
	Total	200	72,822	11,066	783	71,279	74,365	49,910	107,829
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,478	2,056	206	25,070	25,886	21,164	31,710
	Total	200	25,589	1,988	141	25,312	25,866	21,164	31,710
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	85,503,331	1,883,951	188,395	85,129,514	85,877,148	77,008,888	87,773,468
	Total	200	85,661,413	1,815,733	128,392	85,408,230	85,914,596	76,821,611	87,840,602
Sargo	1	100	11	2	0	10	11	7	14
	2	100	11	1	0	10	11	7	16
	Total	200	11	1	0	11	11	7	16
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	211	28	3	205	217	146	297
	Total	200	211	27	2	207	215	146	297
Corvina	1	100	8	1	0	7	8	5	10
	2	100	8	1	0	7	8	5	11
	Total	200	8	1	0	7	8	5	11
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	79,651,696	13,531,226	1,353,123	76,966,807	82,336,585	40,767,566	111,734,630
	Total	200	79,086,562	13,149,771	929,829	77,252,979	80,920,145	40,767,566	111,734,630
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.75	0.15	0.01	0.72	0.78	0.36	1.13
	Total	200	0.75	0.14	0.01	0.73	0.77	0.36	1.13
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	65.49	8.46	0.85	63.81	67.17	45.00	86.00
	Total	200	65.74	8.28	0.59	64.58	66.89	45.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	62.29	8.01	0.80	60.70	63.88	42.76	81.60
	Total	200	62.67	8.32	0.59	61.50	63.83	42.76	86.54

Table B.113 - Real baseline brine extraction increase (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	0.0	1	0.0	3.7	0.057
	Within Groups	0.0	198	0.0		
	Total	0.0	199			
Salinity	Between Groups	36.9	1	36.9	1.6	0.202
	Within Groups	4459.2	198	22.5		
	Total	4496.0	199			
AWPPopSize	Between Groups	79153965.9	1	79153965.9	0.6	0.423
	Within Groups	24290736027.5	198	122680485.0		
	Total	24369889993.4	199			
CBPPopSize	Between Groups	2464046.8	1	2464046.8	0.6	0.431
	Within Groups	783655972.1	198	3957858.4		
	Total	786120018.9	199			
Tilapia	Between Groups	4998001051631.3	1	4998001051631.3	1.5	0.219
	Within Groups	651082471755853.0	198	3288295311898.3		
	Total	656080472807484.0	199			
Sargo	Between Groups	0.0	1	0.0	0.0	0.913
	Within Groups	444.0	198	2.2		
	Total	444.0	199			
Bairdiella	Between Groups	7.7	1	7.7	0.0	0.919
	Within Groups	146736.5	198	741.1		
	Total	146744.1	199			
Corvina	Between Groups	0.0	1	0.0	0.0	0.972
	Within Groups	231.9	198	1.2		
	Total	231.9	199			
FishKilled	Between Groups	63875338283725.6	1	63875338283725.6	0.4	0.545
	Within Groups	34346505192335500.0	198	173467197941088.0		
	Total	34410380530619200.0	199			
FishKill Percent	Between Groups	0.0	1	0.0	0.2	0.649
	Within Groups	3.9	198	0.0		
	Total	3.9	199			
DeathAlgal FishKills	Between Groups	12.0	1	12.0	0.2	0.677
	Within Groups	13621.0	198	68.8		
	Total	13633.0	199			
DeathAlgal FishKillIndex	Between Groups	28.4	1	28.4	0.4	0.523
	Within Groups	13757.9	198	69.5		
	Total	13786.3	199			

Table B.114 - Climate sensitivity analysis (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-233.38	0.01	0.00	-233.38	-233.37	-233.38	-233.37
	3	100	-237.09	0.01	0.00	-237.09	-237.08	-237.09	-237.08
	Total	300	-235.28	1.52	0.09	-235.45	-235.11	-237.09	-233.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	56,533	5	1	56,532	56,534	56,521	56,546
	3	100	61,903	6	1	61,902	61,905	61,891	61,916
	Total	300	59,243	2,196	127	58,993	59,492	56,521	61,916
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	70,388	10,491	1,049	68,306	72,469	48,806	100,326
	3	100	73,062	11,332	1,133	70,813	75,310	47,651	96,447
	Total	300	72,300	10,927	631	71,059	73,542	47,651	100,326
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,213	1,897	190	24,837	25,589	21,120	30,058
	3	100	25,616	2,026	203	25,214	26,018	20,816	29,552
	Total	300	25,510	1,954	113	25,288	25,732	20,816	30,058
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	86,320,888	1,813,165	181,316	85,961,117	86,680,660	80,905,654	88,524,519
	3	100	70,553,593	2,364,631	236,463	70,084,399	71,022,787	58,106,309	72,765,005
	Total	300	80,897,992	7,593,848	438,431	80,035,191	81,760,794	58,106,309	88,524,519
Sargo	1	100	11	2	0	10	11	7	14
	2	100	57	8	1	56	59	40	76
	3	100	0	0	0	0	0	0	0
	Total	300	23	25	1	20	25	0	76
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	304	40	4	296	312	211	396
	3	100	205	27	3	200	210	145	253
	Total	300	240	55	3	233	246	145	396
Corvina	1	100	8	1	0	7	8	5	10
	2	100	32	5	0	31	33	23	43
	3	100	0	0	0	0	0	0	0
	Total	300	13	14	1	12	15	0	43
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	80,905,936	12,885,525	1,288,553	78,349,168	83,462,704	52,520,683	108,355,135
	3	100	79,580,326	13,654,714	1,365,471	76,870,934	82,289,717	54,942,214	113,051,727
	Total	300	79,669,230	13,111,559	756,996	78,179,514	81,158,945	52,520,683	113,051,727
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.76	0.14	0.01	0.74	0.79	0.44	1.10
	3	100	0.77	0.15	0.01	0.74	0.80	0.53	1.18
	Total	300	0.76	0.14	0.01	0.74	0.77	0.44	1.18
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	60.97	8.34	0.83	59.32	62.62	47.00	83.00
	3	100	67.87	7.90	0.79	66.30	69.44	42.00	84.00
	Total	300	64.94	8.61	0.50	63.96	65.92	42.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	57.18	7.86	0.79	55.63	58.74	41.76	79.95
	3	100	65.73	8.12	0.81	64.12	67.34	41.38	85.68
	Total	300	61.99	8.94	0.52	60.97	63.00	41.38	86.54

Table B.115 - Sensitivity analyses' variables and respective parameters

	Variables Analyzed	**Baseline**	**-10%**	**10%**
River Inflows & Precipitation				
	"Future Prcp Climate Scenario"	1	3	2
	"Climate Change Prcp"	1	0.9	1.1
Fish Death Index				
TDS of sea	"Fish Death Algae Bloom Stochastic"	45	40.5	49.5
P of Alamo River Inflow	"Fish Death Algae Bloom Stochastic 10"	45	40.5	49.5
P of New River Inflow	"Fish Death Algae Bloom Stochastic 14"	45	40.5	49.5
Initial Reproductive Rates				
	"Sargo r Setting"	0.6	0.54	0.66
	"Tilapia r Setting"	2	1.8	2.2
	"r for Corvina"	0.1	0.09	0.11
	"r for Bairdiella"	0.6	0.54	0.66
Initial Pelican Populations				
	"American White Pelican"	90,000	81,000	99,000
	"California Brown Pelican"	27,000	24,300	29,700
	"SS Piscivorous Birds AWP"	25,000	22,500	27,500
	"SS Piscivorous Birds CBP"	3,000	2,700	3,300

Table B.116 - Sensitivity analyses (100 repetitions) showing averaged end of year 2024 simulation values

Sensitivity Analyses	Elevation (fasl)	Salinity (mg/L)	AWP #s	CBP #s	Fish Kills	Tilapia #s	Sargo #s	Croaker #s	Corvina #s
Climate									
(D) Baseline	-235.38	59,292	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(S) Baseline	-235.36	59,025	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(D) 10% +	-233.38	56,533	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(S) 10% +	-233.4	56,335	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(D) 10% -	-237.09	61,903	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(S) 10% -	-237.06	61,598	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fish Kill									
(D) Baseline	N/A	N/A	N/A	N/A	66*	85,819,496	11	211	8
(S) Baseline	N/A	N/A	N/A	N/A	66*	81,375,989	23	210	16
(D) 10% +	N/A	N/A	N/A	N/A	75*	85,552,492	11	207	7
(S)10% +	N/A	N/A	N/A	N/A	76*	83,546,177	26	212	18
(D) 10% -	N/A	N/A	N/A	N/A	56*	85,542,998	11	212	8
(S) 10% -	N/A	N/A	N/A	N/A	59*	82,645,578	27	217	19
Fish									
(D) Baseline	N/A	N/A	N/A	N/A	N/A	85,819,496	11	211	8
(S) Baseline	N/A	N/A	N/A	N/A	N/A	81,375,989	23	210	16
(D) 10% +	N/A	N/A	N/A	N/A	N/A	87,481,641*	15*	304*	8*
(S) 10% +	N/A	N/A	N/A	N/A	N/A	84,353,723*	37*	307*	20
(D) 10% -	N/A	N/A	N/A	N/A	N/A	83,248,238*	7*	136*	7*
(S) 10% -	N/A	N/A	N/A	N/A	N/A	80,562,771	19	141*	17
Pelican									
(D) Baseline	N/A	N/A	73,451*	25,700*	N/A	N/A	N/A	N/A	N/A
(S) Baseline	N/A	N/A	72,774*	25,605*	N/A	N/A	N/A	N/A	N/A
(D) 10% +	N/A	N/A	117,548*	40,500*	N/A	N/A	N/A	N/A	N/A
(S) 10% +	N/A	N/A	118,595*	40,689*	N/A	N/A	N/A	N/A	N/A
(D) 10% -	N/A	N/A	48,072*	16,702*	N/A	N/A	N/A	N/A	N/A
(S) 10% -	N/A	N/A	46,887*	16,527*	N/A	N/A	N/A	N/A	N/A

* The mean difference is significant at the 0.05 level.
(D) = Deterministic (strategy 1) and (S) = Stochastic (strategy 2)

Table B.117 - Climate sensitivity analysis (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	689.7	2	344.9	15200536.0	0.000
	Within Groups	0.0	297	0.0		
	Total	689.7	299			
Salinity	Between Groups	1442505659.6	2	721252829.8	24552559.5	0.000
	Within Groups	8724.6	297	29.4		
	Total	1442514384.2	299			
AWPPopSize	Between Groups	556214788.8	2	278107394.4	2.4	0.097
	Within Groups	35143651202.7	297	118328791.9		
	Total	35699865991.5	299			
CBPPopSize	Between Groups	13556290.1	2	6778145.0	1.8	0.170
	Within Groups	1127676729.1	297	3796891.3		
	Total	1141233019.2	299			
Tilapia	Between Groups	16063559961150400.0	2	8031779980575220.0	2023.7	0.000
	Within Groups	1178730387963660.0	297	3968789185062.8		
	Total	17242290349114100.0	299			
Sargo	Between Groups	184099.8	2	92049.9	4325.3	0.000
	Within Groups	6320.7	297	21.3		
	Total	190420.5	299			
Bairdiella	Between Groups	614523.5	2	307261.7	306.9	0.000
	Within Groups	297358.1	297	1001.2		
	Total	911881.6	299			
Corvina	Between Groups	57111.6	2	28555.8	3864.6	0.000
	Within Groups	2194.6	297	7.4		
	Total	59306.2	299			
FishKilled	Between Groups	285479670558440.0	2	142739835279220.0	0.8	0.437
	Within Groups	51116500699226200.0	297	172109429963724.0		
	Total	51401980369784600.0	299			
FishKill Percent	Between Groups	0.0	2	0.0	0.8	0.445
	Within Groups	5.9	297	0.0		
	Total	6.0	299			
DeathAlgal FishKills	Between Groups	2542.7	2	1271.4	19.3	0.000
	Within Groups	19600.2	297	66.0		
	Total	22142.9	299			
DeathAlgal FishKillIndex	Between Groups	3819.5	2	1909.7	28.3	0.000
	Within Groups	20052.9	297	67.5		
	Total	23872.3	299			

Table B.118 - Climate sensitivity analysis (strategy 1): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	-2.00680(*)	0.001	0	-2.008	-2.005
		3	1.70310(*)	0.001	0	1.702	1.705
	2	1	2.00680(*)	0.001	0	2.005	2.008
		3	3.70990(*)	0.001	0	3.708	3.712
	3	1	-1.70310(*)	0.001	0	-1.705	-1.702
		2	-3.70990(*)	0.001	0	-3.712	-3.708
Salinity	1	2	2759.02260(*)	0.767	0	2757.177	2760.868
		3	-2611.53250(*)	0.767	0	-2613.378	-2609.687
	2	1	-2759.02260(*)	0.767	0	-2760.868	-2757.177
		3	-5370.55510(*)	0.767	0	-5372.401	-5368.710
	3	1	2611.53250(*)	0.767	0	2609.687	2613.378
		2	5370.55510(*)	0.767	0	5368.710	5372.401
AWPPopSize	1	2	3063.2944	1538.368	0.142	-640.507	6767.096
		3	389.1095	1538.368	1	-3314.692	4092.911
	2	1	-3063.2944	1538.368	0.142	-6767.096	640.507
		3	-2674.1849	1538.368	0.25	-6377.986	1029.617
	3	1	-389.1095	1538.368	1	-4092.911	3314.692
		2	2674.1849	1538.368	0.25	-1029.617	6377.986
CBPPopSize	1	2	486.9079	275.568	0.235	-176.555	1150.371
		3	83.6576	275.568	1	-579.805	747.120
	2	1	-486.9079	275.568	0.235	-1150.371	176.555
		3	-403.2503	275.568	0.433	-1066.713	260.213
	3	1	-83.6576	275.568	1	-747.120	579.805
		2	403.2503	275.568	0.433	-260.213	1066.713
Tilapia	1	2	-501392.9635	281737.083	0.228	-1179708.081	176922.154
		3	15265902.79900(*)	281737.083	0	14587587.681	15944217.917
	2	1	501392.9635	281737.083	0.228	-176922.154	1179708.081
		3	15767295.76250(*)	281737.083	0	15088980.645	16445610.880
	3	1	-15265902.79900(*)	281737.083	0	-15944217.917	-14587587.681
		2	-15767295.76250(*)	281737.083	0	-16445610.880	-15088980.645
Sargo	1	2	-46.33400(*)	0.652	0	-47.905	-44.763
		3	10.76480(*)	0.652	0	9.194	12.336
	2	1	46.33400(*)	0.652	0	44.763	47.905
		3	57.09880(*)	0.652	0	55.528	58.670
	3	1	-10.76480(*)	0.652	0	-12.336	-9.194
		2	-57.09880(*)	0.652	0	-58.670	-55.528
Bairdiella	1	2	-93.01060(*)	4.475	0	-103.784	-82.237
		3	5.7405	4.475	0.602	-5.033	16.514
	2	1	93.01060(*)	4.475	0	82.237	103.784
		3	98.75110(*)	4.475	0	87.977	109.525
	3	1	-5.7405	4.475	0.602	-16.514	5.033
		2	-98.75110(*)	4.475	0	-109.525	-87.977
Corvina	1	2	-24.78510(*)	0.384	0	-25.711	-23.860
		3	7.50590(*)	0.384	0	6.580	8.431
	2	1	24.78510(*)	0.384	0	23.860	25.711
		3	32.29100(*)	0.384	0	31.366	33.217
	3	1	-7.50590(*)	0.384	0	-8.431	-6.580
		2	-32.29100(*)	0.384	0	-33.217	-31.366

Table B.118 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
FishKilled	1	2	-2384508.657	1855313.612	0.599	-6851394.094	2082376.781
		3	-1058898.006	1855313.612	1	-5525783.443	3407987.431
	2	1	2384508.657	1855313.612	0.599	-2082376.781	6851394.094
		3	1325610.651	1855313.612	1	-3141274.787	5792496.088
	3	1	1058898.006	1855313.612	1	-3407987.431	5525783.443
		2	-1325610.651	1855313.612	1	-5792496.088	3141274.787
FishKillPercent	1	2	-0.0195	0.020	0.989	-0.068	0.029
		3	-0.0239	0.020	0.697	-0.072	0.024
	2	1	0.0195	0.020	0.989	-0.029	0.068
		3	-0.0044	0.020	1	-0.053	0.044
	3	1	0.0239	0.020	0.697	-0.024	0.072
		2	0.0044	0.020	1	-0.044	0.053
DeathAlgal FishKills	1	2	5.010(*)	1.149	0	2.240	7.780
		3	-1.89	1.149	0.303	-4.660	0.880
	2	1	-5.010(*)	1.149	0	-7.780	-2.240
		3	-6.900(*)	1.149	0	-9.670	-4.130
	3	1	1.89	1.149	0.303	-0.880	4.660
		2	6.900(*)	1.149	0	4.130	9.670
DeathAlgal FishKillIndex	1	2	5.85750(*)	1.162	0	3.060	8.655
		3	-2.689	1.162	0.064	-5.487	0.109
	2	1	-5.85750(*)	1.162	0	-8.655	-3.060
		3	-8.54650(*)	1.162	0	-11.344	-5.749
	3	1	2.689	1.162	0.064	-0.109	5.487
		2	8.54650(*)	1.162	0	5.749	11.344

* The mean difference is significant at the .05 level.

Table B.119 - Climate senstivity analysis (strategy 2): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.36	1.00	0.10	-235.55	-235.16	-238.18	-233.23
	2	100	-233.40	1.77	0.18	-233.75	-233.05	-236.52	-227.72
	3	100	-237.06	0.90	0.09	-237.24	-236.88	-238.98	-234.35
	Total	300	-235.27	1.97	0.11	-235.49	-235.05	-238.98	-227.72
Salinity	1	100	59,025	1,450	145	58,737	59,312	56,073	63,380
	2	100	56,335	2,245	225	55,890	56,781	49,703	60,731
	3	100	61,598	1,415	141	61,317	61,879	57,634	64,712
	Total	300	58,986	2,768	160	58,671	59,300	49,703	64,712
AWPPopSize	1	100	72,775	11,918	1,192	70,410	75,139	45,645	105,085
	2	100	73,704	10,902	1,090	71,541	75,868	48,143	104,696
	3	100	70,989	11,263	1,126	68,754	73,224	45,600	105,325
	Total	300	72,489	11,387	657	71,196	73,783	45,600	105,325
CBPPopSize	1	100	25,605	2,121	212	25,184	26,025	20,168	30,839
	2	100	25,808	1,950	195	25,421	26,195	21,011	30,835
	3	100	25,273	2,020	202	24,872	25,673	20,422	30,891
	Total	300	25,562	2,037	118	25,330	25,793	20,168	30,891
Tilapia	1	100	81,375,989	8,065,973	806,597	79,775,525	82,976,453	43,016,635	88,380,289
	2	100	85,794,683	2,758,636	275,864	85,247,310	86,342,057	73,988,514	88,555,342
	3	100	59,976,729	19,581,123	1,958,112	56,091,409	63,862,048	2	87,261,396
	Total	300	75,715,800	16,689,867	963,590	73,819,523	77,612,077	2	88,555,342
Sargo	1	100	23	23	2	18	27	0	68
	2	100	42	18	2	39	46	0	86
	3	100	1	7	1	0	3	0	43
	Total	300	22	24	1	19	25	0	86
Bairdiella	1	100	210	36	4	203	217	139	347
	2	100	231	69	7	217	244	144	584
	3	100	201	32	3	195	207	137	339
	Total	300	214	50	3	208	220	137	584
Corvina	1	100	16	16	2	13	19	0	42
	2	100	28	11	1	26	30	0	42
	3	100	1	5	1	0	2	0	30
	Total	300	15	16	1	13	17	0	42
FishKilled	1	100	78,843,986	13,795,039	1,379,504	76,106,751	81,581,221	49,359,552	120,357,913
	2	100	77,609,842	12,984,326	1,298,433	75,033,470	80,186,214	48,624,530	110,537,877
	3	100	81,858,978	14,068,721	1,406,872	79,067,438	84,650,517	47,339,474	115,282,601
	Total	300	79,437,602	13,695,355	790,702	77,881,557	80,993,647	47,339,474	120,357,913
FishKill Percent	1	100	0.75	0.16	0.02	0.72	0.79	0.44	1.18
	2	100	0.74	0.14	0.01	0.71	0.77	0.45	1.11
	3	100	0.80	0.16	0.02	0.77	0.83	0.44	1.18
	Total	300	0.76	0.15	0.01	0.75	0.78	0.44	1.18
DeathAlgal FishKills	1	100	65.54	8.10	0.81	63.93	67.15	44.00	90.00
	2	100	63.23	8.47	0.85	61.55	64.91	41.00	85.00
	3	100	66.72	8.27	0.83	65.08	68.36	45.00	87.00
	Total	300	65.16	8.38	0.48	64.21	66.12	41.00	90.00
DeathAlgal FishKillIndex	1	100	62.25	8.10	0.81	60.64	63.86	41.81	85.06
	2	100	59.88	9.17	0.92	58.06	61.70	37.51	82.29
	3	100	64.72	8.31	0.83	63.07	66.37	45.77	86.24
	Total	300	62.28	8.74	0.50	61.29	63.27	37.51	86.24

Table B.120 - Climate senstivity senstivity analysis (strategy 2): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	670.9	2	335.4	203.6	0.000
	Within Groups	489.2	297	1.6		
	Total	1160.1	299			
Salinity	Between Groups	1385130746.6	2	692565373.3	227.2	0.000
	Within Groups	905456580.5	297	3048675.4		
	Total	2290587327.1	299			
AWPPopSize	Between Groups	380753917.3	2	190376958.6	1.5	0.231
	Within Groups	38389220432.7	297	129256634.5		
	Total	38769974350.0	299			
CBPPopSize	Between Groups	14604698.9	2	7302349.5	1.8	0.172
	Within Groups	1225530143.5	297	4126364.1		
	Total	1240134842.5	299			
Tilapia	Between Groups	38133998525733300.0	2	19066999262866600.0	125.4	0.000
	Within Groups	45152947875868700.0	297	152030127528178.0		
	Total	83286946401602000.0	299			
Sargo	Between Groups	82900.9	2	41450.5	136.9	0.000
	Within Groups	89935.0	297	302.8		
	Total	172835.9	299			
Bairdiella	Between Groups	45495.9	2	22747.9	9.7	0.000
	Within Groups	695595.7	297	2342.1		
	Total	741091.6	299			
Corvina	Between Groups	35908.8	2	17954.4	135.2	0.000
	Within Groups	39438.1	297	132.8		
	Total	75347.0	299			
FishKilled	Between Groups	955614689702892.0	2	477807344851446.0	2.6	0.078
	Within Groups	55125646064043000.0	297	185608235905869.0		
	Total	56081260753745900.0	299			
FishKill Percent	Between Groups	0.2	2	0.1	4.6	0.011
	Within Groups	6.8	297	0.0		
	Total	7.1	299			
DeathAlgal FishKills	Between Groups	630.3	2	315.1	4.6	0.011
	Within Groups	20378.7	297	68.6		
	Total	21009.0	299			
DeathAlgal FishKillIndex	Between Groups	1172.8	2	586.4	8.0	0.000
	Within Groups	21646.9	297	72.9		
	Total	22819.7	299			

Table B.121 - Climate senstivity analysis (strategy 2): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	-1.95750(*)	0.182	0	-2.395	-1.521
		3	1.70260(*)	0.182	0	1.266	2.140
	2	1	1.95750(*)	0.182	0	1.521	2.395
		3	3.66010(*)	0.182	0	3.223	4.097
	3	1	-1.70260(*)	0.182	0	-2.140	-1.266
		2	-3.66010(*)	0.182	0	-4.097	-3.223
Salinity	1	2	2689.54870(*)	246.928	0	2095.040	3284.057
		3	-2573.35110(*)	246.928	0	-3167.860	-1978.843
	2	1	-2689.54870(*)	246.928	0	-3284.057	-2095.040
		3	-5262.89980(*)	246.928	0	-5857.408	-4668.391
	3	1	2573.35110(*)	246.928	0	1978.843	3167.860
		2	5262.89980(*)	246.928	0	4668.391	5857.408
AWPPopSize	1	2	-929.7794	1607.835	1	-4800.831	2941.272
		3	1785.2084	1607.835	0.803	-2085.843	5656.260
	2	1	929.7794	1607.835	1	-2941.272	4800.831
		3	2714.9878	1607.835	0.277	-1156.063	6586.039
	3	1	-1785.2084	1607.835	0.803	-5656.260	2085.843
		2	-2714.9878	1607.835	0.277	-6586.039	1156.063
CBPPopSize	1	2	-203.2727	287.276	1	-894.923	488.377
		3	332.0463	287.276	0.746	-359.604	1023.696
	2	1	203.2727	287.276	1	-488.377	894.923
		3	535.319	287.276	0.19	-156.331	1226.969
	3	1	-332.0463	287.276	0.746	-1023.696	359.604
		2	-535.319	287.276	0.19	-1226.969	156.331
Tilapia	1	2	-4418694.44440(*)	1743732.362	0.035	-8616934.916	-220453.973
		3	21399259.94640(*)	1743732.362	0	17201019.475	25597500.418
	2	1	4418694.44440(*)	1743732.362	0.035	220453.973	8616934.916
		3	25817954.39080(*)	1743732.362	0	21619713.919	30016194.863
	3	1	-21399259.94640(*)	1743732.362	0	-25597500.418	-17201019.475
		2	-25817954.39080(*)	1743732.362	0	-30016194.863	-21619713.919
Sargo	1	2	-19.22290(*)	2.461	0	-25.148	-13.298
		3	21.47510(*)	2.461	0	15.550	27.400
	2	1	19.22290(*)	2.461	0	13.298	25.148
		3	40.69800(*)	2.461	0	34.773	46.623
	3	1	-21.47510(*)	2.461	0	-27.400	-15.550
		2	-40.69800(*)	2.461	0	-46.623	-34.773
Bairdiella	1	2	-20.31940(*)	6.844	0.01	-36.797	-3.842
		3	9.1478	6.844	0.547	-7.330	25.626
	2	1	20.31940(*)	6.844	0.01	3.842	36.797
		3	29.46720(*)	6.844	0	12.989	45.945
	3	1	-9.1478	6.844	0.547	-25.626	7.330
		2	-29.46720(*)	6.844	0	-45.945	-12.989
Corvina	1	2	-11.76540(*)	1.630	0	-15.689	-7.842
		3	14.96950(*)	1.630	0	11.046	18.893
	2	1	11.76540(*)	1.630	0	7.842	15.689
		3	26.73490(*)	1.630	0	22.811	30.659
	3	1	-14.96950(*)	1.630	0	-18.893	-11.046
		2	-26.73490(*)	1.630	0	-30.659	-22.811

Table B.121 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
FishKilled	1	2	1234143.885	1926697.879	1	-3404607.560	5872895.330
		3	-3014991.796	1926697.879	0.356	-7653743.241	1623759.649
	2	1	-1234143.885	1926697.879	1	-5872895.330	3404607.560
		3	-4249135.681	1926697.879	0.085	-8887887.126	389615.764
	3	1	3014991.796	1926697.879	0.356	-1623759.649	7653743.241
		2	4249135.681	1926697.879	0.085	-389615.764	8887887.126
FishKillPercent	1	2	0.0147	0.021	1	-0.037	0.066
		3	-0.0474	0.021	0.084	-0.099	0.004
	2	1	-0.0147	0.021	1	-0.066	0.037
		3	-.06210(*)	0.021	0.012	-0.114	-0.010
	3	1	0.0474	0.021	0.084	-0.004	0.099
		2	.06210(*)	0.021	0.012	0.010	0.114
DeathAlgal FishKills	1	2	2.31	1.171	0.149	-0.510	5.130
		3	-1.18	1.171	0.944	-4.000	1.640
	2	1	-2.31	1.171	0.149	-5.130	0.510
		3	-3.490(*)	1.171	0.009	-6.310	-0.670
	3	1	1.18	1.171	0.944	-1.640	4.000
		2	3.490(*)	1.171	0.009	0.670	6.310
DeathAlgal FishKillIndex	1	2	2.3732	1.207	0.151	-0.534	5.280
		3	-2.4697	1.207	0.125	-5.377	0.437
	2	1	-2.3732	1.207	0.151	-5.280	0.534
		3	-4.84290(*)	1.207	0	-7.750	-1.936
	3	1	2.4697	1.207	0.125	-0.437	5.377
		2	4.84290(*)	1.207	0	1.936	7.750

* The mean difference is significant at the .05 level.

Table B.122 - The effects of salinity (mg/l) on Salton Sea fish and invertebrate reproduction, growth and survival (adapted from Black 1983)

	Effects of Different Salinity Levels (ppm TDS)						
Species	40,000	45,000	50,000	62,500	75,000 - 80,000	90,000 - 100,000	120,000
Tilapia (*O. mossambicus*)			(1) (g) (2) (e)	(1) (h)			(1) (f)
0rangemouth corvina		(4) (a)		(1) (d)			
Croaker	(2) (a)	(3) (a)			(1) (d)		
Sargo	(2) (a)	(3) (a)		(1) (d)			
Pile worms			(5) (b)		(1) (b)		
Barnacles			(6) (c)		(1, 2) (i)		
Copepods						(1, 2) (j)	

(1) = Adult Mortality
(2) = Larvae Mortality
(3) = Growth Hampered
(4) = Growth Ceases
(5) = Early Life Stage Mortality
(6) = Survival at Least This High

Abbreviations: ppm = parts per million, TDS = Total Dissolved Solids
(a) Lasker et al 1972, (b) Kuhl and Oglesby 1979; Cohen and Hyun 2006, (c) Vittor 1968, (d) Hansen 1970, (e) Popper and Lichatowich 1975, (f) Whitfield and Blaber 1976, (g) Watanabe 1997, (h) Costa-Pierce and Reidel 2000, (i) Simpson and Hurlbert 1998; Cohen and Hyun 2006, (j) Dexter 1993; Cohen and Hyun 2006.

Table B.123 - Fish kill index parameters for sea TDS levels

Salton Sea TDS MgL	Probability of Algal Bloom	Algal Bloom Strength	Salton Sea TDS MgL	Probability of Algal Bloom	Algal Bloom Strength
30,000	0.300	0.200	51,000	0.700	0.700
31,000	0.300	0.200	52,000	0.700	0.700
32,000	0.300	0.200	53,000	0.700	0.700
33,000	0.300	0.200	54,000	0.700	0.700
34,000	0.300	0.200	55,000	0.800	0.800
35,000	0.300	0.400	56,000	0.800	0.800
36,000	0.400	0.400	57,000	0.800	0.800
37,000	0.400	0.400	58,000	0.800	0.800
38,000	0.400	0.400	59,000	0.800	0.800
39,000	0.400	0.400	60,000	0.900	0.900
40,000	0.500	0.500	61,000	0.900	0.900
41,000	0.500	0.500	62,000	0.900	0.900
42,000	0.500	0.500	63,000	0.900	0.900
43,000	0.500	0.500	64,000	0.900	0.900
44,000	0.500	0.500	65,000	0.900	1.000
45,000	0.500	0.600	66,000	0.900	1.000
46,000	0.600	0.600	67,000	0.900	1.000
47,000	0.600	0.600	68,000	0.900	1.000
48,000	0.600	0.600	69,000	0.900	1.000
49,000	0.600	0.600	70,000	1.000	1.000
50,000	0.700	0.700			

Table B.124 - Fish kill index parameters for river flow P levels

River P MgL	Probability Algal Bloom A	Algal Bloom Strength A	Probability Algal Bloom N	Algal Bloom Strength N
0.000	0.000	0.000	0.000	0.000
0.167	0.100	0.300	0.100	0.300
0.333	0.300	0.500	0.300	0.500
0.500	0.400	0.700	0.500	0.700
0.667	0.500	0.800	0.600	0.800
0.833	0.600	0.900	0.700	0.900
1.000	0.700	1.000	0.800	1.000
1.167	0.800	1.000	0.900	1.000
1.333	0.900	1.000	0.900	1.000
1.500	1.000	1.000	1.000	1.000

Table B.125 - Fish kill index parameters for the sea and effect of ambient temperature

Salton Sea TDS MgL	TDS Increased Cold Susceptibility
30,000	0.500
34,000	0.500
38,000	0.500
42,000	1.000
46,000	1.000
50,000	1.000
54,000	1.000
58,000	1.000
62,000	2.000
66,000	2.000
70,000	2.000

Table B.126 - Effect of sea TDS on fish mortality and natality rates

Salton Sea TDS MgL	Fish Death TDS Tilapia	Fish Death TDS Sargo	Fish Death TDS Bairdiella	Fish Death TDS Corvina	TDS Induced r Tilapia	TDS Induced r Sargo	TDS Induced r Bairdiella	TDS Induced r Corvina
30,000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
38,000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
39,000	0.000	0.000	0.000	0.000	1.000	0.900	1.000	0.900
40,000	0.000	0.000	0.000	0.000	1.000	0.800	0.900	0.800
41,000	0.000	0.000	0.000	0.000	1.000	0.600	0.800	0.600
42,000	0.000	0.000	0.000	0.000	1.000	0.400	0.600	0.400
43,000	0.000	0.000	0.000	0.000	1.000	0.200	0.400	0.200
44,000	0.000	0.000	0.000	0.000	1.000	0.100	0.200	0.100
45,000	0.000	0.000	0.000	0.000	1.000	0.100	0.100	0.100
46,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
47,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
48,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
49,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
50,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
51,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
52,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
53,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
54,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
55,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
56,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
57,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
58,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
59,000	0.000	0.000	0.000	0.000	1.000	0.050	0.100	0.050
60,000	0.000	0.100	0.000	0.100	0.800	0.050	0.100	0.050
61,000	0.000	0.400	0.000	0.400	0.600	0.050	0.100	0.050
62,000	0.000	0.800	0.000	0.800	0.500	0.050	0.100	0.050
63,000	0.000	0.999	0.000	0.990	0.400	0.050	0.100	0.050
64,000	0.000	0.999	0.000	0.990	0.300	0.050	0.100	0.050
65,000	0.100	0.999	0.000	0.990	0.200	0.050	0.100	0.050
66,000	0.200	0.999	0.000	0.990	0.100	0.050	0.100	0.050
67,000	0.300	0.999	0.000	0.990	0.010	0.050	0.100	0.050
68,000	0.400	0.999	0.000	0.990	0.010	0.050	0.100	0.050
69,000	0.700	0.999	0.000	0.990	0.010	0.050	0.100	0.050
70,000	0.990	0.999	0.000	0.990	0.010	0.050	0.100	0.050
71,000	0.990	0.999	0.000	0.990	0.010	0.050	0.100	0.050
72,000	0.990	0.999	0.100	0.990	0.010	0.050	0.100	0.050
73,000	0.990	0.999	0.400	0.990	0.010	0.050	0.100	0.050
74,000	0.990	0.999	0.800	0.990	0.010	0.050	0.100	0.050
75,000	0.990	0.999	0.990	0.990	0.010	0.050	0.100	0.050

Table B.127 - Prey switching parameters for pelican consumption

Switch to Tilapia Ratio	Tilapia Switch Multiplier
0.000	1.100
0.100	1.089
0.200	1.045
0.300	0.996
0.400	0.935
0.500	0.869
0.600	0.770
0.700	0.655
0.800	0.501
0.900	0.237
1.000	0.000

Table B.128 - Prey switching parameters for pelican consumption

Ratio to Total Fish	Sargo Ratio in Pelican Diet	Bairdiella Ratio in Pelican Diet	Corvina Ratio in Pelican Diet
0.000	0.000	0.000	0.000
0.030	0.000	0.000	0.000
0.060	0.050	0.050	0.050
0.090	0.200	0.200	0.200
0.120	0.700	0.700	0.700
0.150	0.900	0.900	0.900
0.180	1.000	1.000	1.000
0.210	1.000	1.000	1.000
0.240	1.000	1.000	1.000
0.270	1.000	1.000	1.000
0.300	1.000	1.000	1.000

Table B.129 - Population parameters of selected Salton Sea fish species

Species	Initial Pop.	(r)	Mort. Rate	(K)	Fish Mort. Via Pelican Consumption $Pelican^{-1}$ (Additive)
<u>Tilapia</u>					
(*O. mossambicus*)	90×10^{6}	3.500	0.150	1×10^{7}	0.3*(1000)
<u>Sargo</u>					
(*A. davidsoni*)	18×10^{6}	0.600	0.450	1×10^{7}	0.3*(1000)
<u>Croaker</u>					
(*B. icistia*)	18×10^{6}	0.600	0.450	1×10^{7}	0.3*(1000)
<u>Orangemouth Corvina</u>					
(*C. xanthulus*)	18×10^{6}	0.500	0.400	1×10^{7}	0.1*(1000)

Abbreviations: r = Natality Rate, K = Carrying Capacity, Pop. = Population, Mort. = Mortality

Table B.130 - Population parameters for the Salton Sea & outlying (“other”) pelican populations

Variables	Initial Pop.	r	Mort. Rate	K	Emig. Rate	Max., Min. Emig. Rate (Stochastic)	Immig. Rate
<u>AWP</u>							
Other Population	115,000	0.105	0.100	N/A	0.300	(+.1), (-.1)	1*SS Pop.
SS Population	25,000	N/A	0.100	N/A	1.000	N/A	0.3*Other Pop.
<u>CBP</u>							
Other Population	30,000	0.105	0.100	N/A	0.100	(+.1), (-.1)	1*SS Pop.
SS Population	3,000	N/A	0.100	N/A	1.000	N/A	0.1*Other Pop.

Abbreviations: r = Natality Rate, K = Carrying Capacity, CBP = California Brown Pelican, AWP = American White Pelican, SS = Salton Sea, Pop. = Population, N/A = Not Applicable, Emig. = Emigration, Immig. = Immigration, Mort. = Mortality, Max. = Maximum, Min. = Minimum

Table B.131 - Fish kill parameters for pelican epizootics

Total Fish Killed	AWP Epizootic	CBP Epizootic
0	0.000	0.000
1,000,000	0.050	0.050
2,000,000	0.100	0.100
3,000,000	0.100	0.100
4,000,000	0.200	0.200
5,000,000	0.200	0.200
6,000,000	0.200	0.200
7,000,000	0.300	0.300
8,000,000	0.300	0.300
9,000,000	0.300	0.300
10,000,000	0.300	0.300

Table B.132 - Fish kill sensitivity analysis (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	3	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.38
	Total	300	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	59,292	5	0	59,291	59,293	59,281	59,302
	3	100	59,291	4	0	59,291	59,292	59,283	59,304
	Total	300	59,292	5	0	59,291	59,292	59,277	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	72,796	11,447	1,145	70,525	75,068	47,924	111,467
	3	100	72,811	11,352	1,135	70,558	75,063	44,572	106,511
	Total	300	73,019	11,168	645	71,750	74,288	44,572	111,467
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,499	2,016	202	25,099	25,899	20,732	31,769
	3	100	25,661	2,041	204	25,256	26,066	20,229	31,473
	Total	300	25,620	1,988	115	25,394	25,846	20,229	31,769
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	85,552,492	2,071,305	207,130	85,141,500	85,963,484	74,665,192	87,813,313
	3	100	85,542,998	2,049,529	204,953	85,136,327	85,949,669	78,199,718	87,824,034
	Total	300	85,638,329	1,957,089	112,993	85,415,967	85,860,690	74,665,192	87,840,602
Sargo	1	100	11	2	0	10	11	7	14
	2	100	11	1	0	10	11	7	15
	3	100	11	2	0	11	11	7	16
	Total	300	11	2	0	11	11	7	16
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	207	27	3	202	213	143	298
	3	100	212	31	3	206	218	139	309
	Total	300	210	28	2	207	213	139	309
Corvina	1	100	8	1	0	7	8	5	10
	2	100	7	1	0	7	8	5	11
	3	100	8	1	0	7	8	5	12
	Total	300	7	1	0	7	8	5	12
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	80,890,377	13,704,166	1,370,417	78,171,173	83,609,581	44,921,698	119,074,651
	3	100	77,877,909	13,754,565	1,375,457	75,148,705	80,607,113	40,454,796	115,233,979
	Total	300	79,096,571	13,444,521	776,220	77,569,025	80,624,117	40,454,796	119,074,651
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.79	0.15	0.01	0.76	0.82	0.36	1.22
	3	100	0.72	0.15	0.02	0.69	0.75	0.31	1.17
	Total	300	0.75	0.15	0.01	0.74	0.77	0.31	1.22
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	74.94	8.16	0.82	73.32	76.56	59.00	97.00
	3	100	56.40	7.24	0.72	54.96	57.84	40.00	75.00
	Total	300	65.77	10.90	0.63	64.54	67.01	40.00	97.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	70.14	7.84	0.78	68.58	71.69	53.75	89.29
	3	100	55.35	7.06	0.71	53.95	56.75	40.99	74.61
	Total	300	62.84	9.91	0.57	61.72	63.97	40.99	89.29

Table B.133 - Fish kill sensitivity analysis (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	0.0	2	0.0	0.0	0.980
	Within Groups	0.0	297	0.0		
	Total	0.0	299			
Salinity	Between Groups	5.8	2	2.9	0.1	0.874
	Within Groups	6407.1	297	21.6		
	Total	6412.9	299			
AWPPopSize	Between Groups	27952074.8	2	13976037.4	0.1	0.895
	Within Groups	37265951921.3	297	125474585.6		
	Total	37293903996.0	299			
CBPPopSize	Between Groups	2258761.3	2	1129380.7	0.3	0.753
	Within Groups	1179881189.8	297	3972663.9		
	Total	1182139951.1	299			
Tilapia	Between Groups	4927723165841.1	2	2463861582920.6	0.6	0.527
	Within Groups	1140301046592940.0	297	3839397463275.9		
	Total	1145228769758780.0	299			
Sargo	Between Groups	4.9	2	2.5	1.0	0.372
	Within Groups	733.5	297	2.5		
	Total	738.4	299			
Bairdiella	Between Groups	1272.5	2	636.2	0.8	0.453
	Within Groups	237939.6	297	801.1		
	Total	239212.0	299			
Corvina	Between Groups	2.9	2	1.5	1.1	0.321
	Within Groups	378.9	297	1.3		
	Total	381.8	299			
FishKilled	Between Groups	503366636756066.0	2	251683318378033.0	1.4	0.249
	Within Groups	53542422499454600.0	297	180277516833181.0		
	Total	54045789136210700.0	299			
FishKill Percent	Between Groups	0.3	2	0.1	5.9	0.003
	Within Groups	6.3	297	0.0		
	Total	6.6	299			
DeathAlgal FishKills	Between Groups	17193.0	2	8596.5	139.4	0.000
	Within Groups	18321.6	297	61.7		
	Total	35514.6	299			
DeathAlgal FishKillIndex	Between Groups	10945.5	2	5472.7	88.2	0.000
	Within Groups	18424.8	297	62.0		
	Total	29370.3	299			

Table B.134 - Fish kill sensitivity analaysis (strategy 1): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	0	0.001	1	-0.001	0.001
		3	-0.0001	0.001	1	-0.002	0.001
	2	1	0	0.001	1	-0.001	0.001
		3	-0.0001	0.001	1	-0.002	0.001
	3	1	0.0001	0.001	1	-0.001	0.002
		2	0.0001	0.001	1	-0.001	0.002
Salinity	1	2	0.1794	0.657	1	-1.402	1.761
		3	0.3409	0.657	1	-1.241	1.922
	2	1	-0.1794	0.657	1	-1.761	1.402
		3	0.1615	0.657	1	-1.420	1.743
	3	1	-0.3409	0.657	1	-1.922	1.241
		2	-0.1615	0.657	1	-1.743	1.420
AWPPopSize	1	2	654.8019	1584.138	1	-3159.195	4468.799
		3	639.9821	1584.138	1	-3174.015	4453.979
	2	1	-654.8019	1584.138	1	-4468.799	3159.195
		3	-14.8198	1584.138	1	-3828.817	3799.177
	3	1	-639.9821	1584.138	1	-4453.979	3174.015
		2	14.8198	1584.138	1	-3799.177	3828.817
CBPPopSize	1	2	200.3642	281.875	1	-478.282	879.010
		3	38.765	281.875	1	-639.881	717.411
	2	1	-200.3642	281.875	1	-879.010	478.282
		3	-161.5992	281.875	1	-840.245	517.047
	3	1	-38.765	281.875	1	-717.411	639.881
		2	161.5992	281.875	1	-517.047	840.245
Tilapia	1	2	267003.6864	277106.386	1	-400162.486	934169.859
		3	276497.0217	277106.386	0.958	-390669.151	943663.194
	2	1	-267003.6864	277106.386	1	-934169.859	400162.486
		3	9493.3353	277106.386	1	-657672.837	676659.508
	3	1	-276497.0217	277106.386	0.958	-943663.194	390669.151
		2	-9493.3353	277106.386	1	-676659.508	657672.837
Sargo	1	2	0.2026	0.222	1	-0.333	0.738
		3	-0.1054	0.222	1	-0.641	0.430
	2	1	-0.2026	0.222	1	-0.738	0.333
		3	-0.308	0.222	0.501	-0.843	0.227
	3	1	0.1054	0.222	1	-0.430	0.641
		2	0.308	0.222	0.501	-0.227	0.843
Bairdiella	1	2	3.3238	4.003	1	-6.314	12.961
		3	-1.6246	4.003	1	-11.262	8.013
	2	1	-3.3238	4.003	1	-12.961	6.314
		3	-4.9484	4.003	0.652	-14.586	4.689
	3	1	1.6246	4.003	1	-8.013	11.262
		2	4.9484	4.003	0.652	-4.689	14.586
Corvina	1	2	0.1584	0.160	0.966	-0.226	0.543
		3	-0.0783	0.160	1	-0.463	0.306
	2	1	-0.1584	0.160	0.966	-0.543	0.226
		3	-0.2367	0.160	0.418	-0.621	0.148
	3	1	0.0783	0.160	1	-0.306	0.463
		2	0.2367	0.160	0.418	-0.148	0.621

Table B.134 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
FishKilled	1	2	-2368949.347	1898828.675	0.639	-6940602.409	2202703.715
		3	643518.4323	1898828.675	1	-3928134.630	5215171.494
	2	1	2368949.347	1898828.675	0.639	-2202703.715	6940602.409
		3	3012467.779	1898828.675	0.341	-1559185.283	7584120.841
	3	1	-643518.4323	1898828.675	1	-5215171.494	3928134.630
		2	-3012467.779	1898828.675	0.341	-7584120.841	1559185.283
FishKillPercent	1	2	-0.0475	0.021	0.067	-0.097	0.002
		3	0.0219	0.021	0.87	-0.028	0.072
	2	1	0.0475	0.021	0.067	-0.002	0.097
		3	.06940(*)	0.021	0.003	0.020	0.119
	3	1	-0.0219	0.021	0.87	-0.072	0.028
		2	-.06940(*)	0.021	0.003	-0.119	-0.020
DeathAlgal FishKills	1	2	-8.960(*)	1.111	0	-11.630	-6.290
		3	9.580(*)	1.111	0	6.910	12.250
	2	1	8.960(*)	1.111	0	6.290	11.630
		3	18.540(*)	1.111	0	15.870	21.210
	3	1	-9.580(*)	1.111	0	-12.250	-6.910
		2	-18.540(*)	1.111	0	-21.210	-15.870
DeathAlgal FishKillIndex	1	2	-7.09490(*)	1.114	0	-9.777	-4.413
		3	7.69660(*)	1.114	0	5.015	10.378
	2	1	7.09490(*)	1.114	0	4.413	9.777
		3	14.79150(*)	1.114	0	12.110	17.473
	3	1	-7.69660(*)	1.114	0	-10.378	-5.015
		2	-14.79150(*)	1.114	0	-17.473	-12.110

* The mean difference is significant at the .05 level.

Table B.135 - Fish kill sensitivity analysis (strategy 2): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.36	1.00	0.10	-235.55	-235.16	-238.18	-233.23
	2	100	-234.93	1.22	0.12	-235.17	-234.69	-237.07	-230.50
	3	100	-235.03	1.14	0.11	-235.25	-234.80	-237.28	-232.03
	Total	300	-235.10	1.13	0.07	-235.23	-234.98	-238.18	-230.50
Salinity	1	100	59,025	1,450	145	58,737	59,312	56,073	63,380
	2	100	58,413	1,682	168	58,079	58,747	52,705	61,551
	3	100	58,549	1,610	161	58,229	58,868	54,528	61,983
	Total	300	58,662	1,600	92	58,480	58,844	52,705	63,380
AWPPopSize	1	100	72,775	11,918	1,192	70,410	75,139	45,645	105,085
	2	100	73,960	12,118	1,212	71,556	76,365	49,034	104,936
	3	100	76,098	11,189	1,119	73,878	78,318	50,386	102,886
	Total	300	74,278	11,790	681	72,938	75,617	45,645	105,085
CBPPopSize	1	100	25,605	2,121	212	25,184	26,025	20,168	30,839
	2	100	25,734	2,138	214	25,310	26,158	20,861	30,683
	3	100	26,234	1,972	197	25,842	26,625	21,134	30,604
	Total	300	25,857	2,089	121	25,620	26,095	20,168	30,839
Tilapia	1	100	81,375,989	8,065,973	806,597	79,775,525	82,976,453	43,016,635	88,380,289
	2	100	83,546,177	5,210,694	521,069	82,512,262	84,580,092	66,493,241	88,341,783
	3	100	82,645,578	6,036,810	603,681	81,447,744	83,843,412	60,748,414	88,612,011
	Total	300	82,522,581	6,587,343	380,320	81,774,138	83,271,025	43,016,635	88,612,011
Sargo	1	100	23	23	2	18	27	0	68
	2	100	26	23	2	21	30	0	67
	3	100	27	24	2	22	31	0	63
	Total	300	25	23	1	22	28	0	68
Bairdiella	1	100	210	36	4	203	217	139	347
	2	100	212	38	4	204	220	128	376
	3	100	217	30	3	211	223	143	293
	Total	300	213	35	2	209	217	128	376
Corvina	1	100	16	16	2	13	19	0	42
	2	100	18	16	2	15	21	0	42
	3	100	19	17	2	15	22	0	43
	Total	300	17	16	1	16	19	0	43
FishKilled	1	100	78,843,986	13,795,039	1,379,504	76,106,751	81,581,221	49,359,552	120,357,913
	2	100	79,556,084	14,278,349	1,427,835	76,722,950	82,389,218	51,830,969	122,478,160
	3	100	74,463,051	12,687,329	1,268,733	71,945,609	76,980,492	48,727,772	111,954,703
	Total	300	77,621,040	13,744,006	793,511	76,059,467	79,182,613	48,727,772	122,478,160
FishKill Percent	1	100	0.75	0.16	0.02	0.72	0.79	0.44	1.18
	2	100	0.77	0.16	0.02	0.74	0.80	0.45	1.20
	3	100	0.68	0.14	0.01	0.65	0.71	0.39	1.08
	Total	300	0.74	0.16	0.01	0.72	0.75	0.39	1.20
DeathAlgal FishKills	1	100	65.54	8.10	0.81	63.93	67.15	44.00	90.00
	2	100	75.67	8.86	0.89	73.91	77.43	52.00	93.00
	3	100	58.56	7.40	0.74	57.09	60.03	41.00	80.00
	Total	300	66.59	10.74	0.62	65.37	67.81	41.00	93.00
DeathAlgal FishKillIndex	1	100	62.25	8.10	0.81	60.64	63.86	41.81	85.06
	2	100	70.18	8.65	0.87	68.46	71.90	46.31	87.80
	3	100	57.52	7.64	0.76	56.00	59.03	41.61	80.49
	Total	300	63.32	9.65	0.56	62.22	64.41	41.61	87.80

Table B.136 - Fish kill sensitivity analysis (strategy 2): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	10.0	2	5.0	4.0	0.020
	Within Groups	375.1	297	1.3		
	Total	385.1	299			
Salinity	Between Groups	20633137.0	2	10316568.5	4.1	0.017
	Within Groups	745025271.8	297	2508502.6		
	Total	765658408.9	299			
AWPPopSize	Between Groups	567270192.0	2	283635096.0	2.1	0.130
	Within Groups	40993763846.3	297	138026140.9		
	Total	41561034038.3	299			
CBPPopSize	Between Groups	22079559.8	2	11039779.9	2.6	0.079
	Within Groups	1282751610.8	297	4319029.0		
	Total	1304831170.5	299			
Tilapia	Between Groups	237755073527280.0	2	118877536763640.0	2.8	0.064
	Within Groups	12736777325945400.0	297	42884772141230.3		
	Total	12974532399472700.0	299			
Sargo	Between Groups	742.2	2	371.1	0.7	0.502
	Within Groups	159634.8	297	537.5		
	Total	160377.0	299			
Bairdiella	Between Groups	2329.4	2	1164.7	1.0	0.385
	Within Groups	361135.6	297	1215.9		
	Total	363465.0	299			
Corvina	Between Groups	397.5	2	198.7	0.8	0.465
	Within Groups	76869.0	297	258.8		
	Total	77266.5	299			
FishKilled	Between Groups	1521288888160130.0	2	760644444080067.0	4.1	0.017
	Within Groups	54959121802184900.0	297	185047548155505.0		
	Total	56480410690345000.0	299			
FishKill Percent	Between Groups	0.5	2	0.2	10.1	0.000
	Within Groups	6.8	297	0.0		
	Total	7.3	299			
DeathAlgal FishKills	Between Groups	14803.0	2	7401.5	111.7	0.000
	Within Groups	19685.6	297	66.3		
	Total	34488.6	299			
DeathAlgal FishKillIndex	Between Groups	8184.0	2	4092.0	61.8	0.000
	Within Groups	19677.5	297	66.3		
	Total	27861.6	299			

Table B.137 - Fish kill sensitivity analysis (strategy 2): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Elevation	1	2	-.42650(*)	0.159	0.023	-0.809	-0.044
		3	-0.3284	0.159	0.119	-0.711	0.054
	2	1	.42650(*)	0.159	0.023	0.044	0.809
		3	0.0981	0.159	1	-0.285	0.481
	3	1	0.3284	0.159	0.119	-0.054	0.711
		2	-0.0981	0.159	1	-0.481	0.285
Salinity	1	2	611.60370(*)	223.987	0.02	72.329	1150.878
		3	475.9569	223.987	0.103	-63.317	1015.231
	2	1	-611.60370(*)	223.987	0.02	-1150.878	-72.329
		3	-135.6468	223.987	1	-674.921	403.628
	3	1	-475.9569	223.987	0.103	-1015.231	63.317
		2	135.6468	223.987	1	-403.628	674.921
AWPPopSize	1	2	-1185.8723	1661.482	1	-5186.086	2814.341
		3	-3323.1986	1661.482	0.139	-7323.412	677.015
	2	1	1185.8723	1661.482	1	-2814.341	5186.086
		3	-2137.3263	1661.482	0.598	-6137.540	1862.887
	3	1	3323.1986	1661.482	0.139	-677.015	7323.412
		2	2137.3263	1661.482	0.598	-1862.887	6137.540
CBPPopSize	1	2	-129.3194	293.906	1	-836.932	578.293
		3	-629.1513	293.906	0.099	-1336.764	78.461
	2	1	129.3194	293.906	1	-578.293	836.932
		3	-499.8319	293.906	0.27	-1207.445	207.781
	3	1	629.1513	293.906	0.099	-78.461	1336.764
		2	499.8319	293.906	0.27	-207.781	1207.445
Tilapia	1	2	-2170188.164	926118.482	0.059	-4399927.186	59550.859
		3	-1269589.621	926118.482	0.514	-3499328.643	960149.402
	2	1	2170188.164	926118.482	0.059	-59550.859	4399927.186
		3	900598.543	926118.482	0.995	-1329140.480	3130337.566
	3	1	1269589.621	926118.482	0.514	-960149.402	3499328.643
		2	-900598.543	926118.482	0.995	-3130337.566	1329140.480
Sargo	1	2	-2.6374	3.279	1	-10.531	5.256
		3	-3.751	3.279	0.761	-11.645	4.143
	2	1	2.6374	3.279	1	-5.256	10.531
		3	-1.1136	3.279	1	-9.007	6.780
	3	1	3.751	3.279	0.761	-4.143	11.645
		2	1.1136	3.279	1	-6.780	9.007
Bairdiella	1	2	-1.9269	4.931	1	-13.800	9.946
		3	-6.6341	4.931	0.539	-18.507	5.239
	2	1	1.9269	4.931	1	-9.946	13.800
		3	-4.7072	4.931	1	-16.580	7.166
	3	1	6.6341	4.931	0.539	-5.239	18.507
		2	4.7072	4.931	1	-7.166	16.580
Corvina	1	2	-1.655	2.275	1	-7.133	3.823
		3	-2.8044	2.275	0.656	-8.282	2.673
	2	1	1.655	2.275	1	-3.823	7.133
		3	-1.1494	2.275	1	-6.627	4.328
	3	1	2.8044	2.275	0.656	-2.673	8.282
		2	1.1494	2.275	1	-4.328	6.627

Table B.137 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
FishKilled	1	2	-712098.2178	1923785.581	1	-5343837.963	3919641.528
		3	4380935.208	1923785.581	0.07	-250804.537	9012674.953
	2	1	712098.2178	1923785.581	1	-3919641.528	5343837.963
		3	5093033.42580(*)	1923785.581	0.026	461293.680	9724773.171
	3	1	-4380935.208	1923785.581	0.07	-9012674.953	250804.537
		2	-5093033.42580(*)	1923785.581	0.026	-9724773.171	-461293.680
FishKillPercent	1	2	-0.0178	0.021	1	-0.069	0.034
		3	.07310(*)	0.021	0.002	0.022	0.125
	2	1	0.0178	0.021	1	-0.034	0.069
		3	.09090(*)	0.021	0	0.039	0.143
	3	1	-.07310(*)	0.021	0.002	-0.125	-0.022
		2	-.09090(*)	0.021	0	-0.143	-0.039
DeathAlgal FishKills	1	2	-10.13000(*)	1.151	0	-12.902	-7.358
		3	6.98000(*)	1.151	0	4.208	9.752
	2	1	10.13000(*)	1.151	0	7.358	12.902
		3	17.11000(*)	1.151	0	14.338	19.882
	3	1	-6.98000(*)	1.151	0	-9.752	-4.208
		2	-17.11000(*)	1.151	0	-19.882	-14.338
DeathAlgal FishKillIndex	1	2	-7.92970(*)	1.151	0	-10.701	-5.158
		3	4.73000(*)	1.151	0	1.959	7.502
	2	1	7.92970(*)	1.151	0	5.158	10.701
		3	12.65970(*)	1.151	0	9.888	15.431
	3	1	-4.73000(*)	1.151	0	-7.502	-1.959
		2	-12.65970(*)	1.151	0	-15.431	-9.888

* The mean difference is significant at the .05 level.

Table B.138 - Fish sensitivity analysis (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	3	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	Total	300	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	59,291	4	0	59,290	59,292	59,279	59,300
	3	100	59,291	5	0	59,290	59,292	59,277	59,301
	Total	300	59,291	5	0	59,291	59,292	59,277	59,306
AWPPopSize	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	70,456	12,062	1,206	68,062	72,849	40,662	97,831
	3	100	74,438	11,064	1,106	72,243	76,634	47,381	105,861
	Total	300	72,782	11,409	659	71,485	74,078	40,662	105,861
CBPPopSize	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	25,141	2,165	217	24,711	25,571	19,268	29,567
	3	100	25,934	1,966	197	25,544	26,324	20,783	31,336
	Total	300	25,591	2,041	118	25,360	25,823	19,268	31,336
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	87,481,641	1,971,918	197,192	87,090,370	87,872,913	80,555,933	89,574,353
	3	100	83,248,238	2,076,833	207,683	82,836,150	83,660,327	76,969,899	85,767,893
	Total	300	85,516,458	2,600,188	150,122	85,221,029	85,811,888	76,821,611	89,574,353
Sargo	1	100	11	2	0	10	11	7	14
	2	100	15	2	0	15	16	10	20
	3	100	7	1	0	7	8	5	11
	Total	300	11	4	0	11	12	5	20
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	304	42	4	296	313	198	393
	3	100	136	21	2	132	140	90	203
	Total	300	217	75	4	208	226	90	393
Corvina	1	100	8	1	0	7	8	5	10
	2	100	8	1	0	8	9	5	11
	3	100	7	1	0	7	7	5	10
	Total	300	8	1	0	7	8	5	11
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	82,674,171	15,094,915	1,509,491	79,679,012	85,669,329	56,946,523	125,319,869
	3	100	77,192,658	13,558,721	1,355,872	74,502,314	79,883,003	42,621,614	115,246,877
	Total	300	79,462,752	14,001,110	808,354	77,871,967	81,053,537	42,621,614	125,319,869
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.76	0.16	0.02	0.73	0.79	0.48	1.23
	3	100	0.76	0.16	0.02	0.73	0.80	0.36	1.18
	Total	300	0.76	0.15	0.01	0.74	0.77	0.36	1.23
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	65.27	7.64	0.76	63.75	66.79	47.00	86.00
	3	100	65.28	8.75	0.88	63.54	67.02	49.00	87.00
	Total	300	65.51	8.17	0.47	64.58	66.44	47.00	87.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	62.15	7.40	0.74	60.68	63.62	43.09	83.02
	3	100	61.97	8.52	0.85	60.28	63.66	45.57	85.59
	Total	300	62.39	8.20	0.47	61.46	63.32	43.09	86.54

Table B.139 - Fish sensitivity analysis (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	0.0	2	0.0	1.6	0.198
	Within Groups	0.0	297	0.0		
	Total	0.0	299			
Salinity	Between Groups	65.4	2	32.7	1.5	0.225
	Within Groups	6466.5	297	21.8		
	Total	6531.9	299			
AWPPopSize	Between Groups	860287458.3	2	430143729.1	3.4	0.036
	Within Groups	38056609350.1	297	128136731.8		
	Total	38916896808.4	299			
CBPPopSize	Between Groups	33158212.7	2	16579106.3	4.1	0.018
	Within Groups	1211864172.1	297	4080350.7		
	Total	1245022384.8	299			
Tilapia	Between Groups	909859763504330.0	2	454929881752165.0	121.5	0.000
	Within Groups	1111672853305400.0	297	3743006240085.5		
	Total	2021532616809730.0	299			
Sargo	Between Groups	3097.5	2	1548.8	516.5	0.000
	Within Groups	890.5	297	3.0		
	Total	3988.0	299			
Bairdiella	Between Groups	1416397.2	2	708198.6	736.2	0.000
	Within Groups	285706.2	297	962.0		
	Total	1702103.4	299			
Corvina	Between Groups	122.3	2	61.2	45.0	0.000
	Within Groups	403.5	297	1.4		
	Total	525.8	299			
FishKilled	Between Groups	1635262600634940.0	2	817631300317469.0	4.3	0.015
	Within Groups	56978032027421400.0	297	191845225681554.0		
	Total	58613294628056400.0	299			
FishKill Percent	Between Groups	0.0	2	0.0	0.5	0.630
	Within Groups	7.0	297	0.0		
	Total	7.0	299			
DeathAlgal FishKills	Between Groups	33.1	2	16.6	0.2	0.781
	Within Groups	19903.8	297	67.0		
	Total	19937.0	299			
DeathAlgal FishKillIndex	Between Groups	65.8	2	32.9	0.5	0.614
	Within Groups	20015.8	297	67.4		
	Total	20081.6	299			

Table B.140 - Fish sensitivity analysis (strategy 1): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	-0.0005	0.001	1	-0.002	0.001
		3	-0.001	0.001	0.217	-0.002	0.000
	2	1	0.0005	0.001	1	-0.001	0.002
		3	-0.0005	0.001	1	-0.002	0.001
	3	1	0.001	0.001	0.217	0.000	0.002
		2	0.0005	0.001	1	-0.001	0.002
Salinity	1	2	0.7026	0.660	0.864	-0.886	2.291
		3	1.1326	0.660	0.261	-0.456	2.721
	2	1	-0.7026	0.660	0.864	-2.291	0.886
		3	0.43	0.660	1	-1.159	2.019
	3	1	-1.1326	0.660	0.261	-2.721	0.456
		2	-0.43	0.660	1	-2.019	1.159
AWPPopSize	1	2	2995.3862	1600.854	0.187	-858.859	6849.631
		3	-987.2733	1600.854	1	-4841.518	2866.972
	2	1	-2995.3862	1600.854	0.187	-6849.631	858.859
		3	-3982.65950(*)	1600.854	0.04	-7836.904	-128.415
	3	1	987.2733	1600.854	1	-2866.972	4841.518
		2	3982.65950(*)	1600.854	0.04	128.415	7836.904
CBPPopSize	1	2	558.6795	285.669	0.154	-129.103	1246.462
		3	-233.7695	285.669	1	-921.552	454.013
	2	1	-558.6795	285.669	0.154	-1246.462	129.103
		3	-792.44900(*)	285.669	0.018	-1480.232	-104.666
	3	1	233.7695	285.669	1	-454.013	921.552
		2	792.44900(*)	285.669	0.018	104.666	1480.232
Tilapia	1	2	-1662145.94490(*)	273605.784	0	-2320884.005	-1003407.885
		3	2571257.05210(*)	273605.784	0	1912518.992	3229995.112
	2	1	1662145.94490(*)	273605.784	0	1003407.885	2320884.005
		3	4233402.99700(*)	273605.784	0	3574664.937	4892141.057
	3	1	-2571257.05210(*)	273605.784	0	-3229995.112	-1912518.992
		2	-4233402.99700(*)	273605.784	0	-4892141.057	-3574664.937
Sargo	1	2	-4.43090(*)	0.245	0	-5.021	-3.841
		3	3.41820(*)	0.245	0	2.829	4.008
	2	1	4.43090(*)	0.245	0	3.841	5.021
		3	7.84910(*)	0.245	0	7.260	8.439
	3	1	-3.41820(*)	0.245	0	-4.008	-2.829
		2	-7.84910(*)	0.245	0	-8.439	-7.260
Bairdiella	1	2	-93.53680(*)	4.386	0	-104.097	-82.976
		3	74.40960(*)	4.386	0	63.849	84.970
	2	1	93.53680(*)	4.386	0	82.976	104.097
		3	167.94640(*)	4.386	0	157.386	178.507
	3	1	-74.40960(*)	4.386	0	-84.970	-63.849
		2	-167.94640(*)	4.386	0	-178.507	-157.386
Corvina	1	2	-.77420(*)	0.165	0	-1.171	-0.377
		3	.78990(*)	0.165	0	0.393	1.187
	2	1	.77420(*)	0.165	0	0.377	1.171
		3	1.56410(*)	0.165	0	1.167	1.961
	3	1	-.78990(*)	0.165	0	-1.187	-0.393
		2	-1.56410(*)	0.165	0	-1.961	-1.167

Table B.140 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
FishKilled	1	2	-4152743.035	1958801.806	0.104	-8868788.453	563302.383
		3	1328769.152	1958801.806	1	-3387276.267	6044814.570
	2	1	4152743.035	1958801.806	0.104	-563302.383	8868788.453
		3	5481512.18630(*)	1958801.806	0.016	765466.768	10197557.604
	3	1	-1328769.152	1958801.806	1	-6044814.570	3387276.267
		2	-5481512.18630(*)	1958801.806	0.016	-10197557.604	-765466.768
FishKillPercent	1	2	-0.0163	0.022	1	-0.069	0.036
		3	-0.0195	0.022	1	-0.072	0.033
	2	1	0.0163	0.022	1	-0.036	0.069
		3	-0.0032	0.022	1	-0.056	0.049
	3	1	0.0195	0.022	1	-0.033	0.072
		2	0.0032	0.022	1	-0.049	0.056
DeathAlgal FishKills	1	2	0.71	1.158	1	-2.080	3.500
		3	0.7	1.158	1	-2.090	3.490
	2	1	-0.71	1.158	1	-3.500	2.080
		3	-0.01	1.158	1	-2.800	2.780
	3	1	-0.7	1.158	1	-3.490	2.090
		2	0.01	1.158	1	-2.780	2.800
DeathAlgal FishKillIndex	1	2	0.8902	1.161	1	-1.905	3.685
		3	1.0719	1.161	1	-1.723	3.867
	2	1	-0.8902	1.161	1	-3.685	1.905
		3	0.1817	1.161	1	-2.614	2.977
	3	1	-1.0719	1.161	1	-3.867	1.723
		2	-0.1817	1.161	1	-2.977	2.614

* The mean difference is significant at the .05 level.

Table B.141 - Fish sensitivity analysis (strategy 2): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Elevation	1	100	-235.36	1.00	0.10	-235.55	-235.16	-238.18	-233.23
	2	100	-234.91	1.27	0.13	-235.16	-234.65	-237.78	-231.81
	3	100	-235.01	1.26	0.13	-235.26	-234.76	-238.18	-231.18
	Total	300	-235.09	1.19	0.07	-235.23	-234.95	-238.18	-231.18
Salinity	1	100	59,025	1,450	145	58,737	59,312	56,073	63,380
	2	100	58,385	1,760	176	58,035	58,734	54,329	62,607
	3	100	58,518	1,749	175	58,171	58,865	53,519	63,288
	Total	300	58,643	1,676	97	58,452	58,833	53,519	63,380
AWPPopSize	1	100	72,775	11,918	1,192	70,410	75,139	45,645	105,085
	2	100	71,248	10,445	1,044	69,175	73,320	52,047	98,308
	3	100	76,262	12,178	1,218	73,846	78,679	50,456	103,922
	Total	300	73,428	11,691	675	72,100	74,756	45,645	105,085
CBPPopSize	1	100	25,605	2,121	212	25,184	26,025	20,168	30,839
	2	100	25,296	1,875	188	24,924	25,668	21,636	29,801
	3	100	26,253	2,118	212	25,833	26,674	21,578	30,572
	Total	300	25,718	2,073	120	25,483	25,954	20,168	30,839
Tilapia	1	100	81,375,989	8,065,973	806,597	79,775,525	82,976,453	43,016,635	88,380,289
	2	100	84,353,723	6,189,519	618,952	83,125,588	85,581,858	56,015,914	90,248,492
	3	100	80,562,771	6,873,795	687,379	79,198,861	81,926,681	43,085,264	86,390,818
	Total	300	82,097,494	7,248,099	418,469	81,273,976	82,921,012	43,016,635	90,248,492
Sargo	1	100	23	23	2	18	27	0	68
	2	100	37	32	3	31	43	0	112
	3	100	19	17	2	15	22	0	90
	Total	300	26	26	1	23	29	0	112
Bairdiella	1	100	210	36	4	203	217	139	347
	2	100	308	59	6	296	319	222	698
	3	100	141	50	5	131	151	91	588
	Total	300	219	84	5	210	229	91	698
Corvina	1	100	16	16	2	13	19	0	42
	2	100	20	17	2	17	23	0	46
	3	100	17	14	1	14	20	0	43
	Total	300	18	16	1	16	19	0	46
FishKilled	1	100	78,843,986	13,795,039	1,379,504	76,106,751	81,581,221	49,359,552	120,357,913
	2	100	81,731,366	12,983,456	1,298,346	79,155,166	84,307,565	54,834,339	109,291,026
	3	100	75,459,809	14,147,497	1,414,750	72,652,639	78,266,979	49,903,725	111,356,614
	Total	300	78,678,387	13,845,082	799,346	77,105,330	80,251,444	49,359,552	120,357,913
FishKill Percent	1	100	0.75	0.16	0.02	0.72	0.79	0.44	1.18
	2	100	0.76	0.14	0.01	0.73	0.79	0.48	1.07
	3	100	0.75	0.17	0.02	0.72	0.78	0.43	1.15
	Total	300	0.75	0.15	0.01	0.74	0.77	0.43	1.18
DeathAlgal FishKills	1	100	65.54	8.10	0.81	63.93	67.15	44.00	90.00
	2	100	66.03	7.69	0.77	64.50	67.56	49.00	86.00
	3	100	66.25	9.18	0.92	64.43	68.07	45.00	92.00
	Total	300	65.94	8.33	0.48	64.99	66.89	44.00	92.00
DeathAlgal FishKillIndex	1	100	62.25	8.10	0.81	60.64	63.86	41.81	85.06
	2	100	63.32	7.90	0.79	61.75	64.89	44.93	81.28
	3	100	63.14	9.31	0.93	61.29	64.99	42.81	89.63
	Total	300	62.90	8.44	0.49	61.94	63.86	41.81	89.63

Table B.142 - Fish sensitivity analysis (strategy 2): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	11.2	2	5.6	4.0	0.019
	Within Groups	415.0	297	1.4		
	Total	426.1	299			
Salinity	Between Groups	22791644.0	2	11395822.0	4.1	0.017
	Within Groups	817496443.8	297	2752513.3		
	Total	840288087.9	299			
AWPPopSize	Between Groups	1321507723.9	2	660753862.0	5.0	0.008
	Within Groups	39545719778.4	297	133150571.6		
	Total	40867227502.3	299			
CBPPopSize	Between Groups	47720946.5	2	23860473.2	5.7	0.004
	Within Groups	1237427884.3	297	4166423.9		
	Total	1285148830.7	299			
Tilapia	Between Groups	796651534173466.0	2	398325767086733.0	7.9	0.000
	Within Groups	14911293241914600.0	297	50206374551901.0		
	Total	15707944776088100.0	299			
Sargo	Between Groups	18135.0	2	9067.5	15.2	0.000
	Within Groups	177676.3	297	598.2		
	Total	195811.3	299			
Bairdiella	Between Groups	1403649.6	2	701824.8	289.1	0.000
	Within Groups	721099.2	297	2427.9		
	Total	2124748.8	299			
Corvina	Between Groups	874.1	2	437.0	1.8	0.167
	Within Groups	72048.9	297	242.6		
	Total	72923.0	299			
FishKilled	Between Groups	1970734827158410.0	2	985367413579203.0	5.3	0.006
	Within Groups	55343463465280700.0	297	186341627829228.0		
	Total	57314198292439100.0	299			
FishKill Percent	Between Groups	0.0	2	0.0	0.2	0.852
	Within Groups	7.1	297	0.0		
	Total	7.1	299			
DeathAlgal FishKills	Between Groups	26.4	2	13.2	0.2	0.828
	Within Groups	20712.5	297	69.7		
	Total	20738.9	299			
DeathAlgal FishKillIndex	Between Groups	65.9	2	32.9	0.5	0.631
	Within Groups	21250.0	297	71.5		
	Total	21315.9	299			

Table B.143 - Fish sensitivity analysis (strategy 2): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Elevation	1	2	-.45000(*)	0.167	0.023	-0.853	-0.048
		3	-0.3491	0.167	0.113	-0.752	0.053
	2	1	.45000(*)	0.167	0.023	0.048	0.853
		3	0.1009	0.167	1	-0.302	0.503
	3	1	0.3491	0.167	0.113	-0.053	0.752
		2	-0.1009	0.167	1	-0.503	0.302
Salinity	1	2	639.94430(*)	234.628	0.02	75.050	1204.839
		3	506.327	234.628	0.095	-58.567	1071.221
	2	1	-639.94430(*)	234.628	0.02	-1204.839	-75.050
		3	-133.6173	234.628	1	-698.512	431.277
	3	1	-506.327	234.628	0.095	-1071.221	58.567
		2	133.6173	234.628	1	-431.277	698.512
AWPPopSize	1	2	1526.9833	1631.874	1	-2401.944	5455.911
		3	-3487.8443	1631.874	0.1	-7416.772	441.083
	2	1	-1526.9833	1631.874	1	-5455.911	2401.944
		3	-5014.82760(*)	1631.874	0.007	-8943.755	-1085.900
	3	1	3487.8443	1631.874	0.1	-441.083	7416.772
		2	5014.82760(*)	1631.874	0.007	1085.900	8943.755
CBPPopSize	1	2	308.2518	288.667	0.859	-386.747	1003.251
		3	-648.7127	288.667	0.076	-1343.712	46.286
	2	1	-308.2518	288.667	0.859	-1003.251	386.747
		3	-956.96450(*)	288.667	0.003	-1651.964	-261.966
	3	1	648.7127	288.667	0.076	-46.286	1343.712
		2	956.96450(*)	288.667	0.003	261.966	1651.964
Tilapia	1	2	-2977734.49880(*)	1002061.620	0.01	-5390315.547	-565153.451
		3	813217.8823	1002061.620	1	-1599363.166	3225798.931
	2	1	2977734.49880(*)	1002061.620	0.01	565153.451	5390315.547
		3	3790952.38110(*)	1002061.620	0.001	1378371.333	6203533.429
	3	1	-813217.8823	1002061.620	1	-3225798.931	1599363.166
		2	-3790952.38110(*)	1002061.620	0.001	-6203533.429	-1378371.333
Sargo	1	2	-13.93500(*)	3.459	0	-22.263	-5.607
		3	4.2747	3.459	0.653	-4.053	12.603
	2	1	13.93500(*)	3.459	0	5.607	22.263
		3	18.20970(*)	3.459	0	9.882	26.538
	3	1	-4.2747	3.459	0.653	-12.603	4.053
		2	-18.20970(*)	3.459	0	-26.538	-9.882
Bairdiella	1	2	-97.32480(*)	6.968	0	-114.102	-80.548
		3	69.45050(*)	6.968	0	52.673	86.228
	2	1	97.32480(*)	6.968	0	80.548	114.102
		3	166.77530(*)	6.968	0	149.998	183.553
	3	1	-69.45050(*)	6.968	0	-86.228	-52.673
		2	-166.77530(*)	6.968	0	-183.553	-149.998
Corvina	1	2	-3.955	2.203	0.221	-9.258	1.348
		3	-0.8029	2.203	1	-6.106	4.500
	2	1	3.955	2.203	0.221	-1.348	9.258
		3	3.1521	2.203	0.46	-2.151	8.455
	3	1	0.8029	2.203	1	-4.500	6.106
		2	-3.1521	2.203	0.46	-8.455	2.151

Table B.143 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
FishKilled	1	2	-2887379.811	1930500.597	0.407	-7535286.747	1760527.124
		3	3384177.199	1930500.597	0.242	-1263729.737	8032084.134
	2	1	2887379.811	1930500.597	0.407	-1760527.124	7535286.747
		3	6271557.00990(*)	1930500.597	0.004	1623650.075	10919463.945
	3	1	-3384177.199	1930500.597	0.242	-8032084.134	1263729.737
		2	-6271557.00990(*)	1930500.597	0.004	-10919463.945	-1623650.075
FishKillPercent	1	2	-0.0068	0.022	1	-0.060	0.046
		3	0.0056	0.022	1	-0.047	0.058
	2	1	0.0068	0.022	1	-0.046	0.060
		3	0.0124	0.022	1	-0.040	0.065
	3	1	-0.0056	0.022	1	-0.058	0.047
		2	-0.0124	0.022	1	-0.065	0.040
DeathAlgal FishKills	1	2	-0.49	1.181	1	-3.330	2.350
		3	-0.71	1.181	1	-3.550	2.130
	2	1	0.49	1.181	1	-2.350	3.330
		3	-0.22	1.181	1	-3.060	2.620
	3	1	0.71	1.181	1	-2.130	3.550
		2	0.22	1.181	1	-2.620	3.060
DeathAlgal FishKillIndex	1	2	-1.0723	1.196	1	-3.952	1.808
		3	-0.8912	1.196	1	-3.771	1.989
	2	1	1.0723	1.196	1	-1.808	3.952
		3	0.1811	1.196	1	-2.699	3.061
	3	1	0.8912	1.196	1	-1.989	3.771
		2	-0.1811	1.196	1	-3.061	2.699

* The mean difference is significant at the .05 level.

Table B.144 - Pelican sensitivity analysis (strategy 1): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Elevation	1	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	2	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	3	100	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
	Total	300	-235.38	0.00	0.00	-235.38	-235.38	-235.39	-235.37
Salinity	1	100	59,292	5	1	59,291	59,293	59,277	59,306
	2	100	59,291	5	0	59,290	59,292	59,280	59,303
	3	100	59,292	5	1	59,291	59,293	59,279	59,304
	Total	300	59,292	5	0	59,291	59,292	59,277	59,306
TotalAWP	1	100	73,451	10,794	1,079	71,309	75,593	49,910	98,473
	2	100	117,548	18,321	1,832	113,912	121,183	76,072	175,104
	3	100	48,072	7,396	740	46,605	49,540	25,892	65,073
	Total	300	79,690	31,536	1,821	76,107	83,273	25,892	175,104
TotalCBP	1	100	25,700	1,921	192	25,319	26,081	21,433	29,917
	2	100	40,500	3,214	321	39,862	41,137	32,516	49,777
	3	100	16,702	1,307	131	16,442	16,961	12,251	19,579
	Total	300	27,634	10,089	582	26,487	28,780	12,251	49,777
SSAWP	1	100	18,570	2,743	274	18,025	19,114	10,493	23,862
	2	100	25,303	2,933	293	24,721	25,885	16,821	32,553
	3	100	12,071	2,033	203	11,668	12,475	5,372	16,936
	Total	300	18,648	5,999	346	17,966	19,330	5,372	32,553
SSCBP	1	100	3,427	336	34	3,360	3,494	2,245	3,964
	2	100	4,548	392	39	4,470	4,626	2,898	5,002
	3	100	2,211	256	26	2,160	2,261	1,343	2,738
	Total	300	3,395	1,012	58	3,280	3,510	1,343	5,002
AWPpop	1	100	54,881	8,410	841	53,213	56,550	37,907	81,781
	2	100	92,245	16,038	1,604	89,063	95,427	56,877	142,551
	3	100	36,001	5,561	556	34,898	37,105	20,520	49,668
	Total	300	61,042	25,824	1,491	58,108	63,976	20,520	142,551
CBPpop	1	100	22,273	1,710	171	21,934	22,612	18,709	27,437
	2	100	35,952	3,133	313	35,330	36,573	28,700	44,977
	3	100	14,491	1,120	112	14,269	14,714	10,908	17,185
	Total	300	24,239	9,143	528	23,200	25,277	10,908	44,977
Tilapia	1	100	85,819,495	1,739,920	173,992	85,474,258	86,164,733	76,821,611	87,840,602
	2	100	85,414,960	2,145,293	214,529	84,989,287	85,840,633	75,257,643	87,765,271
	3	100	85,282,721	2,001,261	200,126	84,885,627	85,679,814	79,677,085	87,810,695
	Total	300	85,505,725	1,976,003	114,085	85,281,215	85,730,236	75,257,643	87,840,602
Sargo	1	100	11	2	0	10	11	7	14
	2	100	11	2	0	10	11	7	16
	3	100	11	2	0	11	11	6	16
	Total	300	11	2	0	11	11	6	16
Bairdiella	1	100	211	26	3	205	216	154	267
	2	100	211	31	3	205	217	140	298
	3	100	214	29	3	208	220	115	281
	Total	300	212	29	2	209	215	115	298
Corvina	1	100	8	1	0	7	8	5	10
	2	100	8	1	0	7	8	5	11
	3	100	8	1	0	7	8	4	11
	Total	300	8	1	0	7	8	4	11

Table B.144 - (Continued)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
FishKilled	1	100	78,521,428	12,800,012	1,280,001	75,981,627	81,061,228	53,820,624	110,607,852
	2	100	78,587,022	13,977,088	1,397,709	75,813,665	81,360,380	41,487,626	115,966,699
	3	100	77,279,560	14,077,523	1,407,752	74,486,274	80,072,846	49,576,948	136,357,427
	Total	300	78,129,337	13,598,243	785,095	76,584,325	79,674,348	41,487,626	136,357,427
FishKill Percent	1	100	0.74	0.14	0.01	0.72	0.77	0.49	1.12
	2	100	0.75	0.16	0.02	0.72	0.78	0.36	1.21
	3	100	0.73	0.15	0.02	0.70	0.76	0.44	1.34
	Total	300	0.74	0.15	0.01	0.72	0.76	0.36	1.34
DeathAlgal FishKills	1	100	65.98	8.13	0.81	64.37	67.59	49.00	87.00
	2	100	64.95	7.38	0.74	63.49	66.41	50.00	86.00
	3	100	66.44	8.09	0.81	64.84	68.04	48.00	97.00
	Total	300	65.79	7.87	0.45	64.90	66.68	48.00	97.00
DeathAlgal FishKillIndex	1	100	63.04	8.65	0.86	61.33	64.76	44.49	86.54
	2	100	61.68	7.82	0.78	60.13	63.23	46.57	85.72
	3	100	63.62	7.58	0.76	62.12	65.13	46.92	91.38
	Total	300	62.78	8.04	0.46	61.87	63.70	44.49	91.38

Table B.145 - Pelican sensitivity analysis (strategy 1): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	0.0	2	0.0	0.7	0.490
	Within Groups	0.0	297	0.0		
	Total	0.0	299			
Salinity	Between Groups	30.7	2	15.4	0.6	0.532
	Within Groups	7215.0	297	24.3		
	Total	7245.7	299			
TotalAWP	Between Groups	247181095353.3	2	123590547676.7	731.5	0.000
	Within Groups	50182283255.5	297	168963916.7		
	Total	297363378608.8	299			
TotalCBP	Between Groups	28878147462.0	2	14439073731.0	2753.8	0.000
	Within Groups	1557256231.8	297	5243287.0		
	Total	30435403693.7	299			
SSAWP	Between Groups	8754513276.0	2	4377256638.0	648.1	0.000
	Within Groups	2006015715.7	297	6754261.7		
	Total	10760528991.7	299			
SSCBP	Between Groups	273381495.9	2	136690747.9	1234.5	0.000
	Within Groups	32885523.6	297	110725.7		
	Total	306267019.5	299			
AWPpop	Between Groups	163863094469.0	2	81931547234.5	684.9	0.000
	Within Groups	35526932613.2	297	119619301.7		
	Total	199390027082.1	299			
CBPpop	Between Groups	23606763656.4	2	11803381828.2	2530.3	0.000
	Within Groups	1385450597.8	297	4664816.8		
	Total	24992214254.2	299			
Tilapia	Between Groups	15642105880976.5	2	7821052940488.2	2.0	0.135
	Within Groups	1151829949194460.0	297	3878215317153.1		
	Total	1167472055075440.0	299			
Sargo	Between Groups	1.1	2	0.5	0.2	0.822
	Within Groups	798.2	297	2.7		
	Total	799.3	299			
Bairdiella	Between Groups	611.0	2	305.5	0.4	0.692
	Within Groups	245994.3	297	828.3		
	Total	246605.3	299			
Corvina	Between Groups	0.6	2	0.3	0.2	0.801
	Within Groups	406.4	297	1.4		
	Total	407.0	299			
FishKilled	Between Groups	108533159151076.0	2	54266579575538.1	0.3	0.747
	Within Groups	55180219206556500.0	297	185791983860460.0		
	Total	55288752365707600.0	299			
FishKill Percent	Between Groups	0.0	2	0.0	0.7	0.479
	Within Groups	6.6	297	0.0		
	Total	6.6	299			
DeathAlgal FishKills	Between Groups	116.4	2	58.2	0.9	0.392
	Within Groups	18403.4	297	62.0		
	Total	18519.8	299			
DeathAlgal FishKillIndex	Between Groups	198.4	2	99.2	1.5	0.216
	Within Groups	19147.4	297	64.5		
	Total	19345.9	299			

Table B.146 - Pelican sensitivity analysis (strategy 1): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	-0.0005	0.001	1	-0.002	0.001
		3	0.0002	0.001	1	-0.001	0.002
	2	1	0.0005	0.001	1	-0.001	0.002
		3	0.0007	0.001	0.74	-0.001	0.002
	3	1	-0.0002	0.001	1	-0.002	0.001
		2	-0.0007	0.001	0.74	-0.002	0.001
Salinity	1	2	0.5738	0.697	1	-1.104	2.252
		3	-0.1753	0.697	1	-1.854	1.503
	2	1	-0.5738	0.697	1	-2.252	1.104
		3	-0.7491	0.697	0.85	-2.427	0.929
	3	1	0.1753	0.697	1	-1.503	1.854
		2	0.7491	0.697	0.85	-0.929	2.427
TotalAWP	1	2	-44096.82830(*)	1838.281	0	-48522.707	-39670.950
		3	25378.56900(*)	1838.281	0	20952.691	29804.447
	2	1	44096.82830(*)	1838.281	0	39670.950	48522.707
		3	69475.39730(*)	1838.281	0	65049.519	73901.276
	3	1	-25378.56900(*)	1838.281	0	-29804.447	-20952.691
		2	-69475.39730(*)	1838.281	0	-73901.276	-65049.519
TotalCBP	1	2	-14799.90990(*)	323.830	0	-15579.568	-14020.252
		3	8998.03920(*)	323.830	0	8218.381	9777.698
	2	1	14799.90990(*)	323.830	0	14020.252	15579.568
		3	23797.94910(*)	323.830	0	23018.291	24577.607
	3	1	-8998.03920(*)	323.830	0	-9777.698	-8218.381
		2	-23797.94910(*)	323.830	0	-24577.607	-23018.291
SSAWP	1	2	-6732.98590(*)	367.539	0	-7617.880	-5848.092
		3	6498.48930(*)	367.539	0	5613.595	7383.384
	2	1	6732.98590(*)	367.539	0	5848.092	7617.880
		3	13231.47520(*)	367.539	0	12346.581	14116.370
	3	1	-6498.48930(*)	367.539	0	-7383.384	-5613.595
		2	-13231.47520(*)	367.539	0	-14116.370	-12346.581
SSCBP	1	2	-1121.33370(*)	47.059	0	-1234.633	-1008.035
		3	1216.31950(*)	47.059	0	1103.020	1329.619
	2	1	1121.33370(*)	47.059	0	1008.035	1234.633
		3	2337.65320(*)	47.059	0	2224.354	2450.952
	3	1	-1216.31950(*)	47.059	0	-1329.619	-1103.020
		2	-2337.65320(*)	47.059	0	-2450.952	-2224.354
AWPpop	1	2	-37363.84220(*)	1546.734	0	-41087.786	-33639.898
		3	18880.07950(*)	1546.734	0	15156.136	22604.023
	2	1	37363.84220(*)	1546.734	0	33639.898	41087.786
		3	56243.92170(*)	1546.734	0	52519.978	59967.866
	3	1	-18880.07950(*)	1546.734	0	-22604.023	-15156.136
		2	-56243.92170(*)	1546.734	0	-59967.866	-52519.978
CBPpop	1	2	-13678.57680(*)	305.444	0	-14413.970	-12943.183
		3	7781.71900(*)	305.444	0	7046.326	8517.113
	2	1	13678.57680(*)	305.444	0	12943.183	14413.970
		3	21460.29580(*)	305.444	0	20724.902	22195.689
	3	1	-7781.71900(*)	305.444	0	-8517.113	-7046.326
		2	-21460.29580(*)	305.444	0	-22195.689	-20724.902

Table B.146 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tilapia	1	2	404535.4696	278503.692	0.442	-265994.880	1075065.819
		3	536774.6534	278503.692	0.165	-133755.696	1207305.003
	2	1	-404535.4696	278503.692	0.442	-1075065.819	265994.880
		3	132239.1838	278503.692	1	-538291.166	802769.534
	3	1	-536774.6534	278503.692	0.165	-1207305.003	133755.696
		2	-132239.1838	278503.692	1	-802769.534	538291.166
Sargo	1	2	-0.0625	0.232	1	-0.621	0.496
		3	-0.1449	0.232	1	-0.703	0.413
	2	1	0.0625	0.232	1	-0.496	0.621
		3	-0.0824	0.232	1	-0.641	0.476
	3	1	0.1449	0.232	1	-0.413	0.703
		2	0.0824	0.232	1	-0.476	0.641
Bairdiella	1	2	-0.5328	4.070	1	-10.332	9.266
		3	-3.2584	4.070	1	-13.058	6.541
	2	1	0.5328	4.070	1	-9.266	10.332
		3	-2.7256	4.070	1	-12.525	7.074
	3	1	3.2584	4.070	1	-6.541	13.058
		2	2.7256	4.070	1	-7.074	12.525
Corvina	1	2	-0.0414	0.165	1	-0.440	0.357
		3	-0.1093	0.165	1	-0.508	0.289
	2	1	0.0414	0.165	1	-0.357	0.440
		3	-0.0679	0.165	1	-0.466	0.330
	3	1	0.1093	0.165	1	-0.289	0.508
		2	0.0679	0.165	1	-0.330	0.466
FishKilled	1	2	-65594.4974	1927651.337	1	-4706641.504	4575452.509
		3	1241867.573	1927651.337	1	-3399179.433	5882914.580
	2	1	65594.4974	1927651.337	1	-4575452.509	4706641.504
		3	1307462.071	1927651.337	1	-3333584.936	5948509.077
	3	1	-1241867.573	1927651.337	1	-5882914.580	3399179.433
		2	-1307462.071	1927651.337	1	-5948509.077	3333584.936
FishKillPercent	1	2	-0.0093	0.021	1	-0.060	0.041
		3	0.016	0.021	1	-0.035	0.067
	2	1	0.0093	0.021	1	-0.041	0.060
		3	0.0253	0.021	0.693	-0.025	0.076
	3	1	-0.016	0.021	1	-0.067	0.035
		2	-0.0253	0.021	0.693	-0.076	0.025
DeathAlgal FishKills	1	2	1.03	1.113	1	-1.650	3.710
		3	-0.46	1.113	1	-3.140	2.220
	2	1	-1.03	1.113	1	-3.710	1.650
		3	-1.49	1.113	0.545	-4.170	1.190
	3	1	0.46	1.113	1	-2.220	3.140
		2	1.49	1.113	0.545	-1.190	4.170
DeathAlgal FishKillIndex	1	2	1.359	1.136	0.697	-1.375	4.093
		3	-0.5819	1.136	1	-3.316	2.152
	2	1	-1.359	1.136	0.697	-4.093	1.375
		3	-1.9409	1.136	0.265	-4.675	0.793
	3	1	0.5819	1.136	1	-2.152	3.316
		2	1.9409	1.136	0.265	-0.793	4.675

* The mean difference is significant at the .05 level.

Table B.147 - Pelican sensitivity analysis (strategy 2): Oneway ANOVA descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Elevation	1	100	-235.36	1.00	0.10	-235.55	-235.16	-238.18	-233.23
	2	100	-235.24	1.18	0.12	-235.47	-235.01	-238.00	-230.64
	3	100	-235.09	1.30	0.13	-235.35	-234.84	-238.03	-230.50
	Total	300	-235.23	1.16	0.07	-235.36	-235.10	-238.18	-230.50
Salinity	1	100	59,025	1,450	145	58,737	59,312	56,073	63,380
	2	100	58,851	1,659	166	58,522	59,180	52,852	62,966
	3	100	58,657	1,787	179	58,303	59,012	52,696	62,980
	Total	300	58,844	1,639	95	58,658	59,031	52,696	63,380
TotalAWP	1	100	72,775	11,918	1,192	70,410	75,139	45,645	105,085
	2	100	118,595	17,844	1,784	115,054	122,136	74,461	166,643
	3	100	46,887	6,862	686	45,526	48,249	33,222	64,847
	Total	300	79,419	32,405	1,871	75,737	83,101	33,222	166,643
TotalCBP	1	100	25,605	2,121	212	25,184	26,025	20,168	30,839
	2	100	40,689	3,136	314	40,067	41,311	32,108	48,548
	3	100	16,527	1,215	121	16,286	16,768	13,839	19,659
	Total	300	27,607	10,241	591	26,443	28,771	13,839	48,548
SSAWP	1	100	18,120	3,139	314	17,497	18,742	9,827	25,380
	2	100	24,972	2,776	278	24,421	25,523	17,392	30,809
	3	100	11,950	2,003	200	11,552	12,347	6,600	16,877
	Total	300	18,347	5,960	344	17,670	19,024	6,600	30,809
SSCBP	1	100	3,346	394	39	3,268	3,424	2,126	4,037
	2	100	4,500	400	40	4,420	4,579	3,055	4,947
	3	100	2,214	246	25	2,165	2,263	1,416	2,746
	Total	300	3,353	999	58	3,240	3,467	1,416	4,947
AWPpop	1	100	54,655	9,066	907	52,856	56,454	33,765	79,705
	2	100	93,623	16,058	1,606	90,437	96,809	56,304	135,834
	3	100	34,938	4,969	497	33,952	35,924	25,809	47,970
	Total	300	61,072	26,783	1,546	58,029	64,115	25,809	135,834
CBPpop	1	100	22,259	1,827	183	21,896	22,621	17,499	26,802
	2	100	36,189	3,138	314	35,567	36,812	28,333	43,867
	3	100	14,313	1,019	102	14,111	14,515	12,306	16,913
	Total	300	24,254	9,313	538	23,196	25,312	12,306	43,867
Tilapia	1	100	81,375,989	8,065,973	806,597	79,775,525	82,976,453	43,016,635	88,380,289
	2	100	81,590,761	7,738,156	773,816	80,055,343	83,126,179	50,772,497	88,098,533
	3	100	82,103,496	7,144,019	714,402	80,685,968	83,521,025	49,635,513	88,451,738
	Total	300	81,690,082	7,639,355	441,058	80,822,110	82,558,054	43,016,635	88,451,738
Sargo	1	100	23	23	2	18	27	0	68
	2	100	21	22	2	17	26	0	61
	3	100	23	22	2	19	28	0	66
	Total	300	22	22	1	20	25	0	68
Bairdiella	1	100	210	36	4	203	217	139	347
	2	100	207	27	3	202	212	133	282
	3	100	210	36	4	203	217	142	378
	Total	300	209	33	2	205	213	133	378
Corvina	1	100	16	16	2	13	19	0	42
	2	100	15	16	2	12	18	0	44
	3	100	16	15	2	13	19	0	45
	Total	300	16	16	1	14	17	0	45

Table B.147 - (Continued)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
FishKilled	1	100	78,843,986	13,795,039	1,379,504	76,106,751	81,581,221	49,359,552	120,357,913
	2	100	78,221,345	12,949,407	1,294,941	75,651,901	80,790,788	44,755,668	119,419,600
	3	100	79,069,034	13,299,191	1,329,919	76,430,186	81,707,883	46,160,565	111,834,417
	Total	300	78,711,455	13,312,500	768,598	77,198,909	80,224,001	44,755,668	120,357,913
FishKill Percent	1	100	0.75	0.16	0.02	0.72	0.79	0.44	1.18
	2	100	0.75	0.15	0.01	0.72	0.78	0.38	1.23
	3	100	0.75	0.15	0.01	0.72	0.78	0.40	1.12
	Total	300	0.75	0.15	0.01	0.73	0.77	0.38	1.23
DeathAlgal FishKills	1	100	65.54	8.10	0.81	63.93	67.15	44.00	90.00
	2	100	66.16	8.03	0.80	64.57	67.75	49.00	89.00
	3	100	66.73	8.35	0.84	65.07	68.39	49.00	89.00
	Total	300	66.14	8.15	0.47	65.22	67.07	44.00	90.00
DeathAlgal FishKillIndex	1	100	62.25	8.10	0.81	60.64	63.86	41.81	85.06
	2	100	62.86	7.93	0.79	61.29	64.44	43.93	84.27
	3	100	63.44	8.71	0.87	61.71	65.17	47.67	88.80
	Total	300	62.85	8.24	0.48	61.91	63.79	41.81	88.80

Table B.148 - Pelican sensitivity analysis (strategy 2): Oneway ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Elevation	Between Groups	3.5	2	1.7	1.3	0.278
	Within Groups	401.8	297	1.4		
	Total	405.3	299			
Salinity	Between Groups	6749299.0	2	3374649.5	1.3	0.286
	Within Groups	796742951.7	297	2682636.2		
	Total	803492250.8	299			
TotalAWP	Between Groups	263721846769.0	2	131860923384.5	779.4	0.000
	Within Groups	50247228687.1	297	169182588.2		
	Total	313969075456.1	299			
TotalCBP	Between Groups	29791321611.0	2	14895660805.5	2827.2	0.000
	Within Groups	1564785604.7	297	5268638.4		
	Total	31356107215.8	299			
SSAWP	Between Groups	8486845400.0	2	4243422700.0	590.2	0.000
	Within Groups	2135216590.0	297	7189281.4		
	Total	10622061990.0	299			
SSCBP	Between Groups	261211072.3	2	130605536.2	1042.0	0.000
	Within Groups	37227666.0	297	125345.7		
	Total	298438738.3	299			
AWPpop	Between Groups	178374975073.5	2	89187487536.7	733.6	0.000
	Within Groups	36108255653.9	297	121576618.4		
	Total	214483230727.4	299			
CBPpop	Between Groups	24525673432.8	2	12262836716.4	2587.1	0.000
	Within Groups	1407796473.9	297	4740055.5		
	Total	25933469906.6	299			
Tilapia	Between Groups	27943074297613.1	2	13971537148806.6	0.2	0.788
	Within Groups	17421621307241200.0	297	58658657600138.7		
	Total	17449564381538800.0	299			
Sargo	Between Groups	261.9	2	130.9	0.3	0.772
	Within Groups	150401.5	297	506.4		
	Total	150663.4	299			
Bairdiella	Between Groups	610.5	2	305.3	0.3	0.756
	Within Groups	323442.2	297	1089.0		
	Total	324052.8	299			
Corvina	Between Groups	86.8	2	43.4	0.2	0.838
	Within Groups	72703.8	297	244.8		
	Total	72790.7	299			
FishKilled	Between Groups	38563553242614.2	2	19281776621307.1	0.1	0.898
	Within Groups	52951014071373700.0	297	178286242664558.0		
	Total	52989577624616300.0	299			
FishKill Percent	Between Groups	0.0	2	0.0	0.0	0.958
	Within Groups	6.9	297	0.0		
	Total	6.9	299			
DeathAlgal FishKills	Between Groups	70.8	2	35.4	0.5	0.588
	Within Groups	19788.0	297	66.6		
	Total	19858.8	299			
DeathAlgal FishKillIndex	Between Groups	70.8	2	35.4	0.5	0.595
	Within Groups	20223.9	297	68.1		
	Total	20294.7	299			

Table B.149 - Pelican sensitivity analysis (strategy 2): Post Hoc Tests Multiple Comparisons Bonferroni

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Elevation	1	2	-0.1147	0.164	1	-0.511	0.281
		3	-0.263	0.164	0.333	-0.659	0.133
	2	1	0.1147	0.164	1	-0.281	0.511
		3	-0.1483	0.164	1	-0.544	0.248
	3	1	0.263	0.164	0.333	-0.133	0.659
		2	0.1483	0.164	1	-0.248	0.544
Salinity	1	2	173.6203	231.631	1	-384.058	731.298
		3	367.2232	231.631	0.342	-190.455	924.901
	2	1	-173.6203	231.631	1	-731.298	384.058
		3	193.6029	231.631	1	-364.075	751.281
	3	1	-367.2232	231.631	0.342	-924.901	190.455
		2	-193.6029	231.631	1	-751.281	364.075
TotalAWP	1	2	-45820.60910(*)	1839.471	0	-50249.350	-41391.868
		3	25887.04720(*)	1839.471	0	21458.306	30315.789
	2	1	45820.60910(*)	1839.471	0	41391.868	50249.350
		3	71707.65630(*)	1839.471	0	67278.915	76136.398
	3	1	-25887.04720(*)	1839.471	0	-30315.789	-21458.306
		2	-71707.65630(*)	1839.471	0	-76136.398	-67278.915
TotalCBP	1	2	-15084.51120(*)	324.612	0	-15866.052	-14302.970
		3	9077.40040(*)	324.612	0	8295.860	9858.941
	2	1	15084.51120(*)	324.612	0	14302.970	15866.052
		3	24161.91160(*)	324.612	0	23380.371	24943.452
	3	1	-9077.40040(*)	324.612	0	-9858.941	-8295.860
		2	-24161.91160(*)	324.612	0	-24943.452	-23380.371
SSAWP	1	2	-6852.43210(*)	379.191	0	-7765.378	-5939.486
		3	6169.91920(*)	379.191	0	5256.973	7082.866
	2	1	6852.43210(*)	379.191	0	5939.486	7765.378
		3	13022.35130(*)	379.191	0	12109.405	13935.298
	3	1	-6169.91920(*)	379.191	0	-7082.866	-5256.973
		2	-13022.35130(*)	379.191	0	-13935.298	-12109.405
SSCBP	1	2	-1153.69940(*)	50.069	0	-1274.247	-1033.152
		3	1131.92160(*)	50.069	0	1011.374	1252.469
	2	1	1153.69940(*)	50.069	0	1033.152	1274.247
		3	2285.62100(*)	50.069	0	2165.074	2406.168
	3	1	-1131.92160(*)	50.069	0	-1252.469	-1011.374
		2	-2285.62100(*)	50.069	0	-2406.168	-2165.074
AWPpop	1	2	-38968.17760(*)	1559.337	0	-42722.465	-35213.890
		3	19717.12900(*)	1559.337	0	15962.842	23471.416
	2	1	38968.17760(*)	1559.337	0	35213.890	42722.465
		3	58685.30660(*)	1559.337	0	54931.019	62439.594
	3	1	-19717.12900(*)	1559.337	0	-23471.416	-15962.842
		2	-58685.30660(*)	1559.337	0	-62439.594	-54931.019
CBPpop	1	2	-13930.81110(*)	307.898	0	-14672.111	-13189.511
		3	7945.47900(*)	307.898	0	7204.179	8686.779
	2	1	13930.81110(*)	307.898	0	13189.511	14672.111
		3	21876.29010(*)	307.898	0	21134.990	22617.590
	3	1	-7945.47900(*)	307.898	0	-8686.779	-7204.179
		2	-21876.29010(*)	307.898	0	-22617.590	-21134.990

Table B.149 - (Continued)

Dependent Variable	(I) trial	(J) trial	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tilapia	1	2	-214772.1444	1083131.180	1	-2822537.678	2392993.389
		3	-727507.6804	1083131.180	1	-3335273.214	1880257.853
	2	1	214772.1444	1083131.180	1	-2392993.389	2822537.678
		3	-512735.536	1083131.180	1	-3120501.070	2095029.998
	3	1	727507.6804	1083131.180	1	-1880257.853	3335273.214
		2	512735.536	1083131.180	1	-2095029.998	3120501.070
Sargo	1	2	1.7478	3.182	1	-5.914	9.410
		3	-0.4057	3.182	1	-8.068	7.256
	2	1	-1.7478	3.182	1	-9.410	5.914
		3	-2.1535	3.182	1	-9.816	5.509
	3	1	0.4057	3.182	1	-7.256	8.068
		2	2.1535	3.182	1	-5.509	9.816
Bairdiella	1	2	3.0281	4.667	1	-8.208	14.264
		3	0.0037	4.667	1	-11.233	11.240
	2	1	-3.0281	4.667	1	-14.264	8.208
		3	-3.0244	4.667	1	-14.261	8.212
	3	1	-0.0037	4.667	1	-11.240	11.233
		2	3.0244	4.667	1	-8.212	14.261
Corvina	1	2	1.058	2.213	1	-4.269	6.385
		3	-0.1515	2.213	1	-5.479	5.176
	2	1	-1.058	2.213	1	-6.385	4.269
		3	-1.2095	2.213	1	-6.537	4.118
	3	1	0.1515	2.213	1	-5.176	5.479
		2	1.2095	2.213	1	-4.118	6.537
FishKilled	1	2	622641.1581	1888312.700	1	-3923693.459	5168975.775
		3	-225048.5008	1888312.700	1	-4771383.118	4321286.117
	2	1	-622641.1581	1888312.700	1	-5168975.775	3923693.459
		3	-847689.6589	1888312.700	1	-5394024.276	3698644.958
	3	1	225048.5008	1888312.700	1	-4321286.117	4771383.118
		2	847689.6589	1888312.700	1	-3698644.958	5394024.276
FishKillPercent	1	2	0.0061	0.021	1	-0.046	0.058
		3	0.0018	0.021	1	-0.050	0.054
	2	1	-0.0061	0.021	1	-0.058	0.046
		3	-0.0043	0.021	1	-0.056	0.047
	3	1	-0.0018	0.021	1	-0.054	0.050
		2	0.0043	0.021	1	-0.047	0.056
DeathAlgal FishKills	1	2	-0.62	1.154	1	-3.400	2.160
		3	-1.19	1.154	0.91	-3.970	1.590
	2	1	0.62	1.154	1	-2.160	3.400
		3	-0.57	1.154	1	-3.350	2.210
	3	1	1.19	1.154	0.91	-1.590	3.970
		2	0.57	1.154	1	-2.210	3.350
DeathAlgal FishKillIndex	1	2	-0.6124	1.167	1	-3.422	2.197
		3	-1.19	1.167	0.926	-4.000	1.620
	2	1	0.6124	1.167	1	-2.197	3.422
		3	-0.5776	1.167	1	-3.387	2.232
	3	1	1.19	1.167	0.926	-1.620	4.000
		2	0.5776	1.167	1	-2.232	3.387

* The mean difference is significant at the .05 level.

APPENDIX C

AAC	All American Canal
DEIS	Draft Environmental Impact Statement
FER	Freshwater Evaporation Rate
Eto	Evapotranspiration Observed
Et	Evapotranspiration
GIS	Geographic Information System
GPS	Geographic Positioning System
ID	Irrigation District
IID	Imperial Irrigation District
IMVs	Imperial Mexicali Valleys
IV	Imperial Valley
LCRB	Lower Colorado River Basin
Maf	Million acre-feet
QSA	Quantification Settlement Agreement
SCERP	Southwest Center for Environmental Research and Policy
SDCWA	San Diego County Water Authority
SG	Specific Gravity
TDS	Total Dissolved Solids
TIBC	Thermal-Indio and Brawley-Calipatria
TIN	Triangulated Irregular Network

USBR	United States Bureau of Reclamation
USGS	United States Geological Survey

VITA

Michael Edward Kjelland received a B.A. in Biology from Valley City State University, Valley City, North Dakota in May 1996, a M.S. in Natural Resources Management from North Dakota State University, Fargo, North Dakota in May 2001, and a Ph.D. in Wildlife and Fisheries Sciences from Texas A&M University, College Station, Texas in December 2008. Michael's address is the following: Ecological Systems Laboratory, Department of Wildlife & Fisheries Sciences, Texas A&M University, College Station, Texas 77840-2258.